# International Banking and Financial Integration: Evidence from German Banks

**Dissertation**
**for the Faculty of Economics, Business Administration and Information Technology of the University of Zurich**

to achieve the title of
Doctor of Philosophy
in Economics

presented by

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approved in September 2012 at the request of

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The Faculty of Economics, Business Administration and Information Technology of the University of Zurich hereby authorises the printing of this Doctoral Thesis, without thereby giving any opinion on the views contained therein.

Zurich, September 19, 2012.

Chairman of the Doctoral Committee: Prof. Dr. Dieter Pfaff

# Preface

While working on this thesis, I have benefited from the ongoing support of many individuals to whom I owe my deep gratitude.

First of all, I would like to thank my supervisors, Mathias Hoffmann and Claudia Buch. Both generously provided me with many opportunities to develop ideas and skills in many respects. I highly appreciate productive conversations and co-operations in a cordial and respectful atmosphere. It was a great pleasure for me to work on joint papers with Claudia Buch and Michael Koetter. I have learned a lot about fruitful teamwork and kind interaction.

All papers included in this thesis have partly been written during visits of the authors to the *Deutsche Bundesbank*. The hospitality of the Bundesbank and access to its bank-level datasets are gratefully acknowledged. I am particularly grateful to Heinz Herrmann, Cordula Munzert, Winfried Rudek, Tobias Schmidt, Elisabetta Fiorentino, Sven Blank and Elena Biewen who supported our work at the Bundesbank. In Fall 2011, I had the outstanding opportunity to spend a semester at Columbia University – I thank Harrison Hong, Jialin Yu, Ben Craig and Mathias Hoffmann for making this possible.

Besides, I would like to express my gratitude for the precious support by the German Merit Foundation (*Studienstiftung des deutschen Volkes, Stiftung Geld und Währung*). Apart from the scholarship, I was given the chance to meet, exchange with and learn from wonderful, charismatic people.

My sincere thanks also go to Christoph Basten, Rahel Suter, my colleagues at the chair of Professor Hoffmann, many friends and fellow musicians who joined me in playing chamber music.

Finally, but most distinctly, I thank my parents, Reinhold and Maria Koch, for their selfless, never-ending support that I hope being able to at least partly return.

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# List of Abbreviations

| | |
|---|---|
| ADF test | Augmented Dickey Fuller Test |
| BaFin.... | Bundesanstalt für Finanzdienstleistungsaufsicht |
| bg1 ...... | Banking group 1: large commercial banks |
| bg2 ..... | Banking group 2: small commercial banks |
| bg3 ..... | Banking group 3: public sector banks |
| bg4 ..... | Banking group 4: cooperative banks |
| CAMEL . | Capitalization, Asset quality, Management, Earnings, Liquidity |
| CEPII ... | Centre d'Etudes Prospectives et d'Informations Internationales |
| DOLS.... | Dynamic Ordinary Least Squares |
| EG test .. | Engle Granger Test |
| FDI...... | Foreign Direct Investment |
| GATS.... | General Agreement on Trade in Services |
| GDP..... | Gross Domestic Product |
| HAC..... | Heteroskedasticity and Autocorrelation consistent |
| IMF ..... | International Monetary Fund |
| IRF...... | Impulse-Response Function |
| KPSS test | Kwiatkowski Phillips Schmidt Shin Test |
| OECD ... | Organisation for Economic Co-operation and Development |
| OLS ..... | Ordinary Least Squares |
| ROE..... | Return on Equity |
| TBS ..... | Balance-Sheet Total |
| UK ...... | United Kingdom |
| US....... | United States |
| USD ..... | US Dollar |
| VECM... | Vector Error Correction Model |
| WDI..... | World Development Indicators |

# 1

# Introduction

The years before the outbreak of the banking crisis in September 2008 saw rapid growth in the international banking business. Banks expanded globally. They entered foreign markets not only by means of cross-border activities but also by launching a network of foreign affiliates. The degree of financial integration seemed to ever intensify. However, freezing interbank markets in the wake of the Lehman collapse in 2008 and scarce liquidity ever since have apparently stalled this process if not reversed it. As the Economist (2012) ascertains "The ability and willingness of banks to compete is unravelling".[1]

My thesis addresses both stages of financial integration: the global expansion as well as the retreat of banks from international markets. Withdrawing banks from the international stage might suggest the outset of the financial sector's disintegration.

The first part studies the determinants of international banking.[2] The second part examines whether international activities shape the risk-market power tradeoff that is inherent to the banking business. Both papers rely on the pre-crisis period and thus reflect times of global expansion. The third part considers how ruptures in the funding conditions of banks lead to balance-sheet reallocations and the associated changes in leverage. Thus, the third part deliberately captures the banking crisis, but also the termination of guarantees for public sector banks in July 2005. A brief outline of all three parts follows after sketching the international activities of German banks and a choice the core literature on international banking with special emphasis on the crisis in 2008.

[1] The Economist, "The retreat from everywhere", 404, 8781 (2012), pp.30-32.

[2] My thesis uses the terms "global" and "international" interchangeably once referring to any cross-border transactions or foreign commercial presence of banks. The term "multinational" indicates that a bank maintains a network of foreign affiliates.

### International Activities of German Banks

Two datasets collected by the *Deutsche Bundesbank* form the backbone of my empirical analysis: "Monthly Balance Sheet Statistics" and the "External Position Report". Both datasets capture comprehensive data on all banks headquartered in Germany. The "External Position Report" distinguishes cross-border activities from foreign commercial presence by means of branches and subsidiaries. Indeed, individual external position reports serve as the German microdata underlying the "International Consolidated Banking Statistics" and "International Locational Banking Statistics" provided by the *Bank of International Settlements.*

Germany's banking sector is divided into public sector banks, cooperative banks and commercial banks. On average, foreign activity accounts for 40% of the balance-sheet total, ranging from 10% in case of small cooperative or savings banks to 70% in case of large banks. Thus, the volume of foreign activity is very concentrated: the 20 largest banks attract more than 80% of the foreign business (see Fiorentino et al., 2010). Figure 1.1 shows how the financial crisis has shaped the different patterns of cross-border and branches' activities. German banks cut down their external assets by almost 25% between October 2008 and December 2009. In parallel to the trade literature, my thesis differentiates between the *intensive* margin as the volume of foreign activity and the *extensive* margin as the respective countries in which banks report any kind of business. Figure 1.2 plots the *intensive* against the *extensive* margin to describe the geographical distribution of German banks' international activities. Remarkably, most banks are heavily engaged in the UK, the US and Switzerland. In terms of the *intensive* margin, the UK and Spain play the dominant role. To conclude, German banks are an important player on global financial markets and have contributed to the deepening of financial integration. Insights from the German data might hence apply to a broader set of industrialized countries.

### Recent Literature

This section reviews the most recent literature on international banking, the financial crisis in 2008 and banks as contributors to the global transmission of shocks. My objective is to situate the underlying papers of my thesis in a quickly growing body of mainly empirical work.

Figure 1.1: Total Foreign Assets and Liabilities

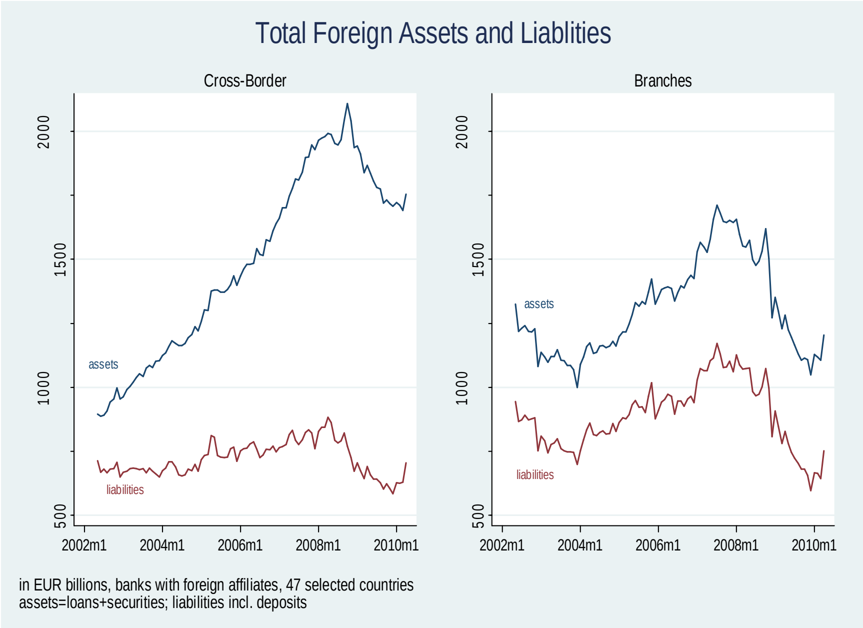
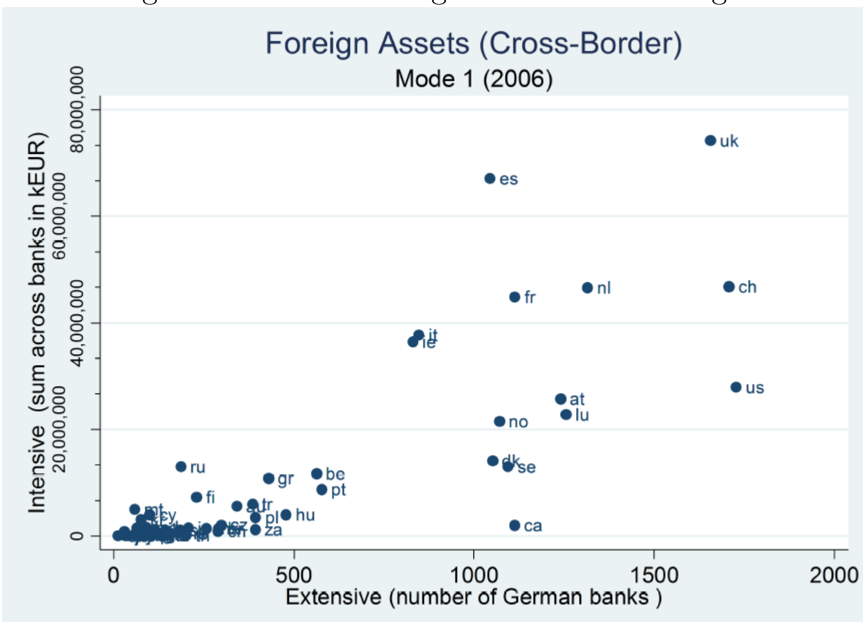



Figure 1.2: Extensive against Intensive Margin



A branch of the banking literature discusses whether foreign bank entry serves as a source of stability to domestic lending. Claessens and Van Horen (2011) point out that foreign banks on average have stronger balance sheets. With respect to developing countries and non-dominant foreign banks, they find that foreign banks cut lending more than domestic banks once affected by the crisis. De Haas and Van Horen (2011) distinguish between cross-border activity and foreign commercial presence. Based on syndicated loan data, they stress that banks exhibit higher commitment to those countries hosting an affiliate.

Frequently, these papers refer to internal capital markets to explain the different behavior of purely domestic and multinational banks. De Haas and Van Lelyveld (2010) find that foreign affiliates benefit from parental support and thus can adjust their lending more flexibly than purely domestic banks. Similarly, Cetorelli and Goldberg (2008) address the role of internal capital markets and monetary policy transmission. They point out that internationally operating banks manage liquidity on a global scale and thus exhibit less sensitivity to domestic policy shocks.

The following papers rely on microdata while dealing with the 2008 crisis' impact on international banking in Europe. Popov and Udell (2010) focus on eastern European countries and find a link between balance-sheet conditions and foreign banks tightening credit standards. Puri et al. (2011) refer to German savings banks that belong to the group of public sector banks. They provide evidence that savings banks associated with head institutions that were severely hit be the US subprime crisis reject significantly more loan applications.

Concerns about the effectiveness of government support schemes has sparked interest in the response of multinational banks. The question arises whether governments put banks under pressure to prioritize domestic customers. Rose and Wieladek (2011) use information on local lending by foreign banks residing in the UK to analyze how support measures targeted at these banks affect their lending. They find that after nationalization, foreign banks reduce the share of their loans going to the UK. Buch et al. (2011a) differentiate between German government support measures and the "TAF program" launched by the *US Federal Reserve*. According to this, German bank affiliates with access to the "TAF program" propagate the effect to associated affiliates located in other foreign countries. Further, Buch et al. (2011a) show that affiliates of those banks that enjoyed support from the German government, expanded their foreign business, but they have not expanded relative to other banks' foreign affiliates.

Indeed, the literature on contagion and the spillover of local financial shocks into foreign markets dates back to the seminal work on Japanese banks by Peek and Rosengren (1997, 2000). Devereux and Yetman (2010) provide more theoretical background. They develop a model in which leverage-constrained investors with an internationally diversified portfolio propagate shocks induced by the impact of asset prices on their balance sheets. Turning back to most recent empirical research, Cetorelli and Goldberg (2011) show that once multinational banks are hit by a funding shock, the treatment of foreign affiliates differs according to their profitability. Bruno and Shin (2012) or Shin (2011) paint the broader picture of European banks as borrowers on wholesale US funding markets and re-channeling these funds via conduits to the US market of credit supply. Cetorelli and Goldberg (2012) expand on this twofold role of foreign banks before and after the financial crisis of 2008. They find that the slimming down of foreign affiliates' balance sheets serves as an example of international shock transmission and as an indicator of internally operating capital markets. Giannetti and Laeven (2012) link the collapsing banking markets to their portfolio reallocation: a "flight home" effect reflects the substitution of foreign loans for domestic syndicated loans.

To conclude, evidence on German microdata underlying my thesis can provide valuable insights for three reasons. First, German banks have substantially contributed to the surge of global banking, the interconnectedness of the business and the deepening of financial integration. Second, the richness and granularity of supervisory datasets can fill gaps uncovered by survey data and aggregates. Third, the architecture of the German banking system allows researchers to distinguish between various types of banks in terms of their institutional background (public sector, cooperative and commercial banks), business model and funding structure.

### Outline of the Three Papers

The first paper explores the determinants of international banking. It draws a parallel to the internationalization of firms and distinguishes between bank-level and country-level determinants. Large, internationally active banks contribute to the integration of financial markets but also to the spreading of shocks across countries. Considerable heterogeneity exists among banks in terms of their productivity and risk preferences that possibly drives bank internationalization. This first paper estimates the ordered probability of banks selecting into distinct modes of foreign market entry (*extensive* margin) and links it to the volume of international assets (*intensive* margin). Methodologically, the paper enriches the conventional Heckman selection model to account for a hierarchy of entry modes on both estimation stages. This paper yields three key findings. First, the fixed costs of engaging in FDI are significantly higher than the fixed costs of engaging in cross-border trade. Second, in addition to productivity, risk factors matter for international banking and, third, gravity-type variables have an important impact on international banking activities.

The second paper analyzes how bank internationalization shapes the domestic market power and risk that is inherent to the banking business. We measure market power by the Lerner index and risk by the official declaration of regulatory authorities that a bank is distressed. Internationalization is proxied by the number of countries in which banks are active (*extensive* margin) and the volume of foreign activities (*intensive* margin). A key contribution of this paper is the ability to distinguish different foreign market entry modes. The paper yields three core findings. First, higher market power is associated with lower risk after accounting for internationalization and tackling simultaneity and endogeneity concerns. Second, banks with higher volumes of foreign activity (*intensive* margin) enjoy higher market power at home. Yet, banks with exposures to more countries (*extensive* margin) see their domestic market power decline. These phenomena are driven by servicing foreign markets via foreign branches rather than cross-border transactions. Managing a too far-flung, complex empire may be increasingly difficult and only the largest, most productive banks are able to reap the profits at home from costly acquired additional information abroad. Third, empirical evidence on the effect of internationalization on bank risk is rather weak. We obtain significant results only when considering the business of foreign branches and the repercussion effects on domestic parent banks. In this light, activities on more foreign markets (*extensive* margin) reduce the domestic parent bank's risk, whereas a higher intensity of foreign operations conducted by branches (*intensive* margin) seems to raise the risk of the domestic parent bank. Diversification benefits thus seem to partly vanish once foreign operations grow large.

The third paper separates short- and long-run dynamics of bank leverage by use of cointegration analysis. With respect to the long-run, if banks' leverage ratio or related liability shares are constant over time, they form a cointegrating relationship. Thus, cointegration tests indicate whether banks target certain liability ratios and whether they have been able to achieve this aim during the banking crisis in 2008. My results reveal that liability ratios are cointegrated only after accounting for structural breaks in the funding conditions of banks. By estimating coefficients on these structural breaks, I can trace the channels of banks' leverage adjustment and unveil their liability reallocations in response to key changes in their funding conditions. With respect to the short-run view, I study the interplay of bank liabilities to correct for deviations from the long-run ratios and their adjustments to changes in financial market risks. In brief, my findings suggest that substantial heterogeneity governs the adjustment patterns of different banking groups to both, key ruptures in their funding conditions and changes in financial market risks.

# 2

# Margins of international banking: Is there a productivity pecking order, too?[1]

Large, internationally active banks drive the integration of financial markets, but they can also contribute to the propagation of shocks across countries. This is one reason why regulators aim at imposing higher capital requirements on large and systemically important banks.[2] Given the importance of international banks, a number of questions about the internationalization of services firms and, in particular, banks remain unanswered.[3] To what extent are the internationalization decisions of banks determined by productivity and risk preferences of banks? Which factors affect the *extensive* (foreign investment decision) and *intensive* (volume of activities) margins? And which factors affect particular modes of activities? In contrast to prior research[4], we explicitly account for bank heterogeneity in terms of productivity and risk preferences. We distinguish among different modes of market entry (international assets, foreign branches, foreign subsidiaries), and

[1] This chapter draws on joint work with Claudia M. Buch and Michael Koetter. It relies on an updated version of Buch et al. (2009). A more concise version of this chapter was published as Buch et al. (2011b) in the *Journal of International Economics* (2011, Copyright by Elsevier). Section 2.4 details on my contribution to these papers.

[2] See Blinder 2010 or Feldman and Stern 2010 for a discussion of current reform proposals.

[3] Bonfiglioli (2008) provides country-level evidence that financial integration reflected in liberalization spurs total factor productivity in the economy but does not analyze the specific role of banks.

[4] See, e.g., Berger et al. 2003; Ruckman 2004; Focarelli and Pozzolo 2005; Buch and Lipponer 2007. Goldberg 2004 discusses the links between literature on financial and non-financial firms' FDI, with a focus on the impact on developing countries. Cetorelli and Goldberg 2008 show how differences in the degree of internationalization of banks can have implications for the effects of monetary policy.

we analyze the *extensive* margin as well as the *intensive* margin.

There is a rich body of literature suggesting that heterogeneity in terms of productivity can explain the foreign expansions of non-financial firms. Larger and more productive firms are more likely to export and engage in foreign direct investment (FDI) than are smaller and less productive firms (see Helpman et al., 2004; Bernard et al., 2006, 2007; Tomiura, 2007; Yeaple, 2009). The explanation for these stylized facts involves the interaction between firm-level productivity and the costs of market entry Melitz (2003); Helpman et al. (2008). Domestic fixed costs are lower than the costs of exporting, which are lower than the costs of FDI. Exporting also entails higher variable costs. Thus, firms self-select into different modes of entry, realizing that the higher the fixed costs of a mode of entry, the higher is the required productivity, which results in a "pecking order of productivity".[5]

Consistent with this literature, Buch et al. (2011a) show patterns of international activities of (German) banks, which correspond to a productivity pecking order But their results also show that other sources of heterogeneity matter as well. Here, we use a regression framework to explicitly account for such other features and to model the sorting of banks into different modes of internationalization. In banking, portfolio effects of international activities are likely to play a role as well. International activities provide the opportunity to diversify risks, but international activities also expose banks to adverse shocks from abroad. Empirically, we therefore include bank-level information on the degree of risk aversion of banks, and we explore how these factors affect internationalization. We find that banks with a higher revealed degree of risk aversion are less likely to go abroad but, once being abroad, the volume of activity is higher.

In addition, our study goes beyond previous evidence in three regards. First, we use a novel and comprehensive dataset that provides detailed information about the internationalization choices of German banks. The "External Position Report" provided by the *Deutsche Bundesbank* contains information about the international assets of German banks, their foreign branches, and their foreign subsidiaries, year-by-year and country-by-country. There have been no minimum reporting thresholds since 2002. Therefore, we have detailed information about all domestic and internationally active German banks.

[5]In international finance literature, the term "pecking order" also describes the structure of different types of international capital flows Daude and Fratzscher (2008).

We find that, in contrast with non-financial firms, many (small) banks hold international assets. In line with evidence for non-financial firms though, few banks have foreign affiliates.

Second, we model the self-selection of banks according to the different modes of foreign activities using an ordered probit, similar to Barattieri (2011). We enrich a conventional Heckman (1979) model by including hierarchical categories in the selection equation. We also show that selection into foreign markets has a significant impact on the volume of activities. Most previous studies focus on large, internationally active banks only,[6] which means they ignore the selection bias inherent in heterogeneous firm (productivity) models.

Third, we take into account the differences in banks' production processes compared with those of non-financial firms. We estimate bank productivity using an empirical methodology often applied to non-financial firms, in the spirit of Levinsohn and Petrin (2003) and applied to banks by Nakane and Weintraub (2005). Alternatively, banking studies often rely on a dual approach in which they estimate deviations from optimal cost frontiers, so-called (in)efficiency, which is an established measure of relative performance in the banking literature Berger et al. (1997); Kumbhakar and Lovell (2003).[7] We find clear evidence for a productivity pecking order in international banking using either measure. Productivity is especially important for smaller banks, such as savings and cooperative banks.

The remainder of this article is structured as follows. In the next section, we offer some background. Section 2.2 contains our data and descriptive statistics, our empirical model, and our measure of bank productivity. After presenting the estimation results in Section 2.3, we conclude in Section 2.4.

## 2.1 Bank Heterogeneity and Internationalization: Theory

To recognize how bank-level productivity and the degree of risk aversion may influence international banking, consider a simple portfolio model of an international bank. In

[6]See Berger et al. (2003); Focarelli and Pozzolo (2005) or Cerutti et al. (2007).

[7]Because (in)efficiency estimation approaches usually neglect the bias that results from the simultaneity between input choices and productivity, we have a preference for the former measure.

the Appendix, we show how a baseline closed-economy portfolio model (Freixas et al., 1997) can be extended to model banks' choice to service foreign markets. Banks can hold international assets through either their domestic headquarters (Mode 1) or foreign affiliates (Mode 2).[8] We assume that banks invest but do not borrow abroad.[9]

The expected profits of a domestic bank $i$ holding international assets in country $j$ depend on the returns on its domestic and international assets less variable costs and the fixed costs of foreign activities. The fixed and variable costs of international operations vary across host countries. We set the fixed costs of domestic operations to 0. We further assume that the fixed costs of operating under Mode 2 are higher than the fixed costs of Mode 1 (see Cerutti et al., 2007). Variable and in particular information costs are lower though if banks maintain a foreign affiliate. Our specification thus involves a trade-off between the fixed and variable costs of foreign activities, similar to that known in trade literature.

Both raising deposits and granting loans is costly for banks because of the costs of handling loan applications, maintaining a branch network, or performing payment services. We assume that banks differ with regard to their productivity ($\omega_i$) and that more productive banks enjoy lower costs: $c_{ij,\bullet} = c_{ij,\bullet}(\omega_i)$ with $\frac{\partial c_{ij,\bullet}(\omega_i)}{\partial \omega_i} < 0$. Each bank thus is characterized by a specific productivity level, which also transfers to its foreign affiliates. The costs of supplying financial services internationally are higher than those in the domestic context, due to institutional and regulatory differences across financial systems and lack of familiarity with the pool of foreign borrowers.

Thus far, our model shares several similarities with models of non-financial firms. The main difference between banks and non-financial firms is that the former care about the risk of their activities. We follow Rochet (2008) and assume that the bank's objective function increases with expected profits and decreases with risk.

We use this model to analyze the *intensive* and *extensive* margins of banks' foreign activities.[10] As to the *extensive* margin, the bank chooses to be active in the foreign

[8]Our terminology differs from the World Trade Organization classification of foreign modes. In the language of *General Agreement on Trade in Services* (GATS), we focus on cross-border supply (Mode 1) and commercial presence (Mode 3). In the empirical model, we also allow for the possibility of remaining a purely domestic bank and distinguish between foreign branches and subsidiaries. Adding these options does not affect the qualitative results of the theoretical model.

[9]Relaxing these assumptions leaves the main qualitative results of the following analysis unaffected. We also abstract from exchange rate risk.

[10]We summarize the results of the comparative static analysis in Table A.2.

country if its expected utility is positive. It is straightforward to show that the probability of investing abroad is higher with (i) lower fixed costs of foreign activity, (ii) lower information costs, (iii) higher bank productivity, and (iv) lower degree of risk aversion. Moreover, banks prefer Mode 2 over Mode 1 if their productivity exceeds a threshold ($\overline{\omega}$) – such that banks with $\omega_i < \overline{\omega}$ choose Mode 1, but banks with $\omega_i > \overline{\omega}$ choose Mode 2 and maintain affiliates abroad – and if the savings of fixed costs associated with entering via Mode 2 are small relative to the higher variable costs under Mode 1.

The volume of international activities, the *intensive* margin, can be analyzed by differentiating the objective function with respect to the volume of international risky assets The model shows that banks will increase the volume of their international assets when they experience higher gross returns, lower information costs, higher productivity and thus lower variable costs, lower risk, lower correlations between domestic and foreign returns, and lower degrees of risk aversion.

In summary, our model shows that bank heterogeneity, with regard to productivity and risk aversion, affect internationalization strategies. It also shows some differences and similarities between banks and non-financial firms. For both types of firms, foreign entry becomes more likely when the fixed costs of foreign activity are lower, the savings associated with variable costs are higher, and productivity is higher. The volume of activities also increases with productivity and falls with variable costs. However, banks also take the risk–return trade-off of their foreign activities into account.

## 2.2 Empirical Methodology

### 2.2.1 Data about Patterns of Internationalization[11]

We analyze the patterns of bank internationalization using a unique and detailed database on banks' international assets, the so-called "External Position Report" filed by the *Deutsche Bundesbank* (see also Buch et al., 2011a). The dataset provides comprehensive information about the international assets of domestic banks, their foreign branches, and their foreign subsidiaries year-by-year and country-by-country. Because we are interested in the longer-run patterns of international banking, we study the database for the

[11]We provide the details in the Data Appendix

pre-crisis years 2002–2006. Reporting thresholds for international assets were abolished in January 2002, therefore, we have exact information about the *extensive* and *intensive* margin of banks' foreign operations and do not face any problems associated with truncation or censoring.

To obtain information about the *extensive* margin of banks' foreign operations, we manually link branches and subsidiaries located in country $j$ to their domestic parent bank $i$. We subsume information about the *intensive* margin of a parent banks' foreign operations by aggregating all assets held in country $j$ across the different modes of foreign activity. We use a composite foreign asset and do not distinguish between different types of assets to keep the analysis tractable. Most of the assets we include are interbank assets. We also complement the *External Position Report* with information from the annual balance sheets and income statements of all banks operating in Germany between 2000 and 2006. Each bank that holds a German banking license must submit these data to the supervisory authorities.

Our dataset therefore contains observations for each bank ($i = 2{,}235$), each destination country ($j = 58$), and each year ($t = 5$). Our data cover both, members of the *Organization for Economic Cooperation and Development* (OECD) and non-OECD countries and yields a comprehensive picture of German banks' foreign activities. We distinguish the following modes of operation: (i) purely domestic banks without foreign activities (Mode 0), (ii) banks that hold international assets through their domestic headquarters (Mode 1), (iii) banks that maintain foreign branches (Mode 2a), and (iv) banks that maintain foreign subsidiaries and/or foreign branches (Mode 2b).

Each observation coded as bank-year-country observation, can be included only once in any of these modes. Hence, our modes are mutually exclusive observational units. The ranking of the modes follows the presumed fixed costs involved. Subsidiaries are legally independent, hold their own equity, and are subject to host-country supervision, so they demand the highest costs in terms of capital requirements and regulatory burden. In addition, foreign subsidiaries often enable large-scale retail operations, which again implies the highest fixed costs, in addition to the regulatory start-up costs (Cerutti et al., 2007).

Buch et al. (2011a) use a similar dataset to establish some stylized facts concerning the internationalization of German banks. They show that only a few, large banks have a commercial presence abroad, consistent with the size pecking order documented for manufacturing firms. These large banks are also active in a larger number of countries and have above-average volumes of activity. However, the relationship between internationalization and productivity also yields two inconsistencies with recent trade models. First, virtually all banks hold at least some foreign assets, irrespective of size or productivity. Second, some fairly unproductive banks maintain commercial presences abroad. In our empirical analysis below, we go beyond this evidence to show how bank productivity affects the *extensive* and the *intensive* margin of international banking, and which additional source of heterogeneity matter.

### 2.2.2 Modeling Extensive and Intensive Margins

Our basic empirical setup is a self-selection model, in the spirit of Heckman (1979). Similar to Barattieri (2011), we replace the conventional selection equation with an ordered probit model to mirror the hierarchy of modes of activities. The *extensive* margin (EM) reflects the discrete decision of banks, whether and through which mode to be present in a foreign market. Our model of bank $i$'s operation in country $j$ in year $t$ thus takes the following form:

$$\begin{aligned} IM_{ijt} &= \alpha X_{ijt} + \sigma_{IM} u_{ijt} \\ EM_{ijt} &= \beta Z_{ijt} + v_{ijt} \end{aligned} \tag{2.1}$$

where $IM_{ijt}$ describes the *intensive* margin, and $\sigma_{IM}$ is the standard error of the *intensive* margin's error term. The error terms $u_{ijt}$ and $v_{ijt}$ are assumed to follow a standard bivariate normal distribution with mean zero, unit variance, and correlation coefficient $\rho$. [12] Errors are independent from the covariates $X$ and $Z$. We can identify the *extensive* and the *intensive* margin if vector $X$ includes a subset of variables in vector $Z$ entering the *intensive* margin estimation (Wooldridge, 2002). For this reason, we use dummies for different banking groups as exclusion restrictions. The covariates capture productivity, other bank-level, and host country-specific variables, which we describe subsequently (Section 2.3.1). Because we can observe the *intensive* margin only if $EM_{ijt} > 0$, and

[12] This specification allows us to apply a standard normal distribution in the correction term, drawing on Winkelmann et al. (2006).

because the error terms are correlated, the ordinary least square (OLS) estimates of $\alpha$ would suffer from a selection bias.

We model the *extensive* margin as an ordered probit model, which yields consistent coefficient estimates of $\beta$, as well as threshold values $\mu_1, \mu_{2a}, \mu_{2b}$ , and , which separate the categories. The probability that a bank self-selects into either one of four mutually exclusive ordinally scaled modes is given by:

$$\begin{aligned}
Pr\left(EM_{ijt} = 0 \mid Z_{ijt}\right) &= \Phi\left(\mu_1 - \beta Z_{ijt}\right) \\
Pr\left(EM_{ijt} = 1 \mid Z_{ijt}\right) &= \Phi\left(\mu_{2a} - \beta Z_{ijt}\right) - \Phi\left(\mu_1 - \beta Z_{ijt}\right) \\
Pr\left(EM_{ijt} = 2a \mid Z_{ijt}\right) &= \Phi\left(\mu_{2b} - \beta Z_{ijt}\right) - \Phi\left(\mu_{2a} - \beta Z_{ijt}\right) \\
Pr\left(EM_{ijt} = 2b \mid Z_{ijt}\right) &= 1 - \Phi\left(\mu_{2b} - \beta Z_{ijt}\right)
\end{aligned} \tag{2.2}$$

This exposition underpins the pecking order of the different modes of foreign activity, because we must have $\mu_1 < \mu_{2a} < \mu_{2b}$ for the probabilities to be positive. Checking whether the threshold parameters $\mu$ indicate an ascending order with significant coefficients and further yield economically reasonable distances from one category to the next supports a pecking-order of entry modes. This is because the estimated cut-off values can be interpreted as proxies for the fixed costs of foreign activity that banks must cover. Equations (A.2) and (A.4) illustrate these fixed costs.

To estimate the determinants of the *intensive* margin, we must take the bias induced by the selection of banks into the different modes into account. For this purpose, we take the conditional expectations of the *intensive* margin:

$$E\left[IM_{ijt} \mid Z_{ijt}, EM_{ijt} = k\right] = \alpha X_{ijt} + \sigma_{IM} E\left[u_{ijt} \mid Z_{ijt}, EM_{ijt} = k\right]$$

where $k = 1, 2a, 2b$ . Using the assumption about the correlation of errors across margins, we can simplify the conditional expectations of the error term in Equation (2.3) to [13]

$$E\left[\rho v_{ijt} \mid EM_{ijt} = k, Z_{ijt}\right] = \rho E\left[v_{ijt} \mid \mu_k - \beta Z_{ijt} < v_{ijt} < \mu_{k+1} - \beta Z_{ijt}\right]$$

[13] See Technical Appendix A.1.2 for details.

which resembles the inverse Mills ratio in a standard Heckman model. We replace the conventional selection equation by an ordered probit model, so our corresponding correction term $\lambda_{ijt}^{k}$ depends on the specific mode chosen by bank $i$. The *intensive* margin thus transforms into:

$$E\left[IM_{ijt} \mid Z_{ijt}, EM_{ijt} = k\right] \;=\; \alpha X_{ijt} + \sigma_{IM} \tag{2.3}$$

with

$$\begin{aligned}
\lambda_{ijt}^{1} &= = \frac{\phi\left(\mu_{1} - \beta Z_{ijt}\right) - \phi\left(\mu_{2a} - \beta Z_{ijt}\right)}{\Phi\left(\mu_{2a} - \beta Z_{ijt}\right) - \Phi\left(\mu_{1} - \beta Z_{ijt}\right)} if\ EM_{ijt} = 1 \\
\lambda_{ijt}^{2a} &= \frac{\phi\left(\mu_{2a} - \beta Z_{ijt}\right) - \phi\left(\mu_{2b} - \beta Z_{ijt}\right)}{\Phi\left(\mu_{2b} - \beta Z_{ijt}\right) - \Phi\left(\mu_{2a} - \beta Z_{ijt}\right)} if\ EM_{ijt} = 2a \\
\lambda_{ijt}^{2b} &= \frac{\phi\left(\mu_{2b} - \beta Z_{ijt}\right)}{1 - \Phi\left(\mu_{2b} - \beta Z_{ijt}\right)} if\ EM_{ijt} = 2b
\end{aligned}$$

The correction term specified in Equation (2.3) performs a function analogous to that of the inverse Mills ratio in a conventional sample selection (Heckman, 1979). Neglecting this term would lead to an omitted variable bias, following from the assumption that $u_{ijt}$ and $v_{ijt}$ in Equation (2.1) are not independent but instead are bivariate normally distributed. Our hierarchical modeling of the *extensive* margin thus contains information that affects the estimation of the *intensive* margin.

### 2.2.3 Measuring Bank Productivity

The availability of an unbiased measure of bank-level productivity $\omega_{it}$ is key to our empirical model. Several banking studies measure total factor productivity using a dual approach, which implies the estimation of cost or profit functions, then attribute productivity changes to factor accumulation, technological change, or changes in efficiency (Kumbhakar and Lovell, 2003). We use a more direct approach based on a production function. As argued by Levinsohn and Petrin (2003), this method avoids the violation of the (often implicit) independence assumption between productivity and the factor input choices of banks (see Technical Appendix A.1.3). The approach is less common in banking literature though (cf. Nakane and Weintraub, 2005, for Brazilian banks). Details are given in the Appendix.

In Table A.2, we summarize descriptive statistics for the variables we use to estimate bank productivity; in TableA.3, we report the parameter estimates for the production functions. These estimates are fairly similar to those reported by Nakane and Weintraub (2005) for Brazilian banks. We reject constant returns to scale ($\beta_1 + \beta_2 + \beta_3 = 1$). Our productivity estimates instead indicate slightly decreasing returns to scale, in line with indirect evidence from dual approaches used to estimate scale cost economies in German banking. For comparison, we also report results from basic OLS regressions, which highlight the severe bias in parameters when we neglect the simultaneity of production choices and bank productivity. The OLS intercept can be interpreted as a Solow productivity residual. Because the estimate of productivity $\omega_{it}$ is bank-specific, the left-hand panel in Table A.3 lacks this entry. We also do not report the parameter estimate of the intermediate input (equity) in the Levinsohn-Petrin specification, because equity is an ancillary parameter, required only to obtain unbiased estimates of productivity.

We report bank productivity and bank-level covariates for the different modes of internationalization in Table A.4. With regard to the CAMEL variables, the patterns in the data are quite clear: More complex and more costly modes of international operations are associated with a lower degree of capitalization, lower reserve holdings, lower loan-loss provisions, lower cost-to-income ratios, lower return on equity, and lower liquidity. These findings match the hypothesis that indicates more productive banks are more likely to be active internationally and function in more complex modes; they also are consistent with a productivity pecking order. In addition, banks with a lower revealed degree of risk aversion are more active internationally.

To check the robustness of our results, we also use alternative productivity measures. The first is cost efficiency, which is obtained from stochastic cost frontier analysis as the systematic deviation from optimal cost due to higher than optimal factor demand by the banking firm (Koetter et al., 2010). Cost efficiency is a relative measure that has been widely used in the banking literature to benchmark banks' abilities to utilize their resources most efficiently (see Berger, 1995). To account for the three-tier banking structure in Germany and for the fact that banks operate under different technology regimes, we estimate both frontiers as latent classes (see Koetter and Poghosyan, 2009).

## 2.3 Empirical Results

### 2.3.1 Baseline Regression Results

The internationalization decision of banks should, according to our theoretical model, depend on various bank-level and country-level parameters.[14] We present the baseline results in Table A.6, using four different specifications: (i) a baseline model only including bank productivity, (ii) the baseline model plus individual bank-level covariates capturing profitability and risk preferences, (iii) the baseline model plus bank- and country-level covariates (excluding regulations), and (iv) the baseline model plus bank- and all country-level covariates (including regulations). The F-tests show that all groups of variables are jointly significant. We lag all variables by one year to mitigate any reverse causality concerns. We split the country-level covariates into two subgroups, because regulatory variables are not available for all countries. Our preferred specification is the full specification (see Columns 4 and 8), which captures the fixed costs of entry. Adding the country-level variables significantly increases the explanatory power, especially for the *extensive* margin (Column 2). In the specification that only features productivity, the $R^2$ is 0.01 for the *extensive* margin (*intensive* margin 0.10), but the value increases as we add bank-level covariates and dummies (0.13 and 0.21) and the country-level variables (0.40 and 0.29).

**Is There a Productivity Pecking Order?**

Our main measure of bank productivity derives from the production function approach described in Section 2.2.3. We expect a positive impact. To account for other aspects of bank productivity, we include the *cost-to-income ratio* (we expect a negative sign), a bank's *return on equity* (expected positive sign), and an indicator variable to give the quintile of the *size* distribution of the bank's assets (from 1 to 5, expected positive sign) (for a similar specification, see Greenaway et al., 2007). Our results support a productivity pecking order in international banking. First, all cut-offs for the *extensive* margin are significantly different from zero, which indicates a hierarchy of internationalization modes. The higher fixed costs of more complex activities abroad appear in the higher cut-off

[14]See also the Data Appendix and Table A.1 for a summary of the expected signs. All variables except the dummy variables and those expressed in percentages are in logs.

values. Simple *t-tests* show the first-stage cut-offs are significantly different from one another.

Second, the estimated cut-offs increase more in absolute terms when we move from Mode 1 to Mode 2a compared with the move from Mode 2a to Mode 2b. Considering the interval length relative to a particular coefficient, such as that for productivity $^{(\mu_{k+1}-\mu_k)}/_{\alpha_{Prod}}$ , we note that productivity must increase significantly for a bank to achieve the next category. According to our estimates, opening a subsidiary does not require much more productivity, because the bank already maintains a branch in a specific country (transition from Mode 2a to 2b). In contrast, the additionally required productivity is considerable if the bank moves from Mode 1 (international assets held domestically) to Modes 2a or 2b:

$$^{(\mu_{2a}-\mu_1)}/_{\alpha_{Prod}} > {}^{(\mu_{2b}-\mu_{2a})}/_{\alpha_{Prod}} \tag{2.4}$$

Third, the correction term in the outcome equation varies by mode of activity, which implies that it captures the hierarchy of cut-offs. Previous studies fail to take this selection into a particular mode of internationalization into account; they focus instead on internationally active banks only. Fourth, productivity has a positive and significant impact on both margins. Paired with the significant cut-offs, this finding offers evidence of a productivity pecking order, which is robust against the addition of other bank-level variables related to productivity. For example, size and return on equity have the expected positive effects.

Table A.9 shows the results using alternative productivity measures. Two results are very robust across the different specifications. First, the cut-off terms are positive and significant, and there is a clear ranking in terms of the magnitudes. As before, the cut-offs are higher for the modes involving FDI rather than cross-border activities only. Second, size has a positive and significant impact throughout. As regards the productivity measures, the cost efficiency measure yields the same qualitative result as the Levinsohn-Petrin measure, and it is significant both for the *extensive* and for the *intensive* margin.

Labor productivity, in contrast, is not a good measure of bank productivity: it is insignificant for the *extensive* margin and negative for the *intensive* margin. This result is, in fact, not very surprising because banking is not a very labor-intensive industry, and the simple labor productivity measure ignores other relevant inputs for the production process. Instead, our results suggest that the banks with higher labor productivity have a lower volume of international activity. This would be consistent with the low degree of internationalization of savings and cooperative banks, which engage in labor-intensive retail banking activities at home.

### Does Risk Aversion Affect International Banking

The productivity pecking order suggests some similarities between banks and non-financial firms. But an important difference remains: Banks take the risk of their foreign activities into account, and this could explain why patterns in the data cannot be explained with productivity alone (Buch et al., 2011a). A bank's *degree of risk aversion* cannot be observed directly, but the CAMEL profile contains four indirect measures of bank risk. Specifically, banks with a low degree of *capitalization*, low *hidden reserves*, high *non-performing loans*, and low *loan-loss provisions* should have higher levels of risk and, ceteris paribus, a low degree of risk aversion.

Our results confirm that the degree of risk aversion is important. Banks that are willing to take on higher risks are more likely to be active internationally; the signs for capitalization and reserves are negative and significant for the *extensive* margin. Signs for loan-loss provisions and non-performing loans may be consistent with this interpretation, but these variables are not significant in our (preferred) full specification.

The picture changes for the *intensive* margin, for which the positive signs for capitalization and loan-loss provisions and the negative sign for non-performing loans suggest less risk-averse (more stable) banks do more business. This result may suggest a demand-side effect. Our dependent variable is a composite asset dominated by interbank activities, and in interbank markets, trust in the stability of market participants represents an important determinant of lending relationships.[15]

Overall, our results indicate that the decision to venture abroad is positively affected by a low degree of risk aversion. Once abroad, less risky banks generate higher business volumes.

[15] The negative sign on hidden reserves is not inconsistent; hidden reserves partly reflect peculiar features of the German accounting system, which may be difficult to verify for foreign partners.

### Additional Bank-Level Variables

Various dummy variables are included to capture heterogeneity across banks in terms of the different banking groups and locations. A (0, 1) dummy for banks located in the former East Germany accounts for the lower degree of international integration of this region compared with the German average. In the selection equation, we also include *banking group* dummies to distinguish large banks, commercial banks, and savings banks from cooperative banks, as the omitted category.

The dummy variables for the *banking groups* are significant. Large, commercial banks are more likely to extend abroad than are cooperative banks (omitted category); savings banks are less likely to do so. Banks headquartered in the former East Germany are significantly less active in international markets. Given that the East German banks have invested abroad though, their volume of activity is above average.[16]

### Market Size

We consistently find a positive impact of market size on the *extensive* margin, in that GDP, GDP per capita, and total German FDI are positive and significant. The impacts of GDP per capita and German FDI are positive and significant on the *intensive* margin as well. The volume of foreign assets correlates negatively with market size (GDP), because we control for the volume of FDI. If we drop FDI, we achieve a positive and significant coefficient. In this sense, our results confirm studies that indicate a link between trade and financial integration (e.g., Aviat and Coeurdacier, 2007; Kalemli-Ozcan et al., 2010).

### Information Costs

In the international finance literature, geographical distance between two countries has become the standard proxy for *information costs* (e.g., Portes and Rey, 2005; Aviat and Coeurdacier, 2007; Daude and Fratzscher, 2008). Providing financial services to more distant markets or setting up distant foreign affiliates should be more costly than doing business in nearby markets, so we expect a negative sign for distance. As an additional proxy of information costs, we specify a composite index for the level of *institutional*

[16] A possible explanation could be the follow-your customer motive. Since only a few East German banks are active internationally, the demand for banking services from home country clients is concentrated on these banks.

*quality* (see also Beck et al., 2006). A higher value indicates better institutional quality; we expect a positive sign.

*Geographic distance*, reveals the expected negative sign for the *extensive* margin. When distance increases by 1%, GDP increases by approximately 1.7% $\left({}^{-\hat{\beta_{Dist}}}/{}_{\hat{\beta_{GDP}}}\right)$ for a bank that chooses the same mode of entry. The positive coefficient of distance for the *intensive* margin again appears due to our inclusion of FDI as our measure for real integration; if we exclude FDI, distance has a negative impact on the *intensive* margin, too. The index of institutional quality is insignificant for the *extensive* and negative for the *intensive* margin; we expected a positive sign. We only find this positive sign for cooperative banks. For these banks with limited international experience, a good information environment is more important than it is for the larger banks (see Table A.8).

**Macroeconomic Portfolio Effects**

For the *portfolio effects*, we proxy for macroeconomic, country-specific risks using the standard deviation of GDP growth (*growth volatility*) in each host country $j$, computed over the past five years.[17] We expect a negative sign. To measure the correlation between domestic and foreign returns, we use the *growth correlation* of German and foreign GDP growth rates for rolling windows of five-year periods and again expect a negative sign, because higher correlations imply less potential for diversification. A dummy for countries in the *Euro area* provides a proxy of the (absence of) exchange rate risk.

Our results support previous studies that use similar data and empirical approaches, in the sense that we find positive impacts of volatility and correlation and thus a "correlation puzzle" (e.g., Portes and Rey, 2005 in equity markets; Aviat and Coeurdacier, 2007 for banking). Both volatility and correlations should have a negative impact on both margins, but we find this effect only for the impact of volatility on the *extensive* margin. Lower exchange rate risk increases German banks' exposure to Euro area countries. The impact on the *extensive* margin is positive if we do not control for country-level covariates, but it is negative in our full specification. German banks have a below-average presence in Euro area countries, presumably because those nearby countries can be served from the home

[17] We compute growth volatility and growth correlations on the basis of residual GDP growth, regressed on a full set of time-fixed effects, to account for general macroeconomic developments that may influence GDP growth.

market. The positive impact of the Euro on cross-border banking (e.g., Kalemli-Ozcan et al., 2010) might cloud different adjustments along the *extensive* and *intensive* margins.

#### Fixed Costs of Foreign Activity

Our first proxy for the fixed costs of foreign activities is *activity restrictions* faced by banks. This is a discrete measure which indicates restrictions on services and products that banks are allowed to offer, and restrictions on non-financial firm ownership and control (Beck et al., 2006). The expected sign is negative because tighter activity restrictions deter foreign activity. A similar reasoning applies to more stringent *capital restrictions*, which is the sum of initial and overall capital stringency requirements per country. Tighter activity restrictions and capital regulations have the expected negative impacts on the *extensive* margin, in support of our use of these variables as proxies for fixed costs. The impact of regulatory restrictions on the volume of activities is positive though; that is, banks that have entered a particular foreign market engage in more activities there. As shown by Table 7, this positive effect is driven by the large banks, whereas for other banking groups, activity and capital restrictions have a negative impact on the volume of activities. Moreover, for these latter banks, the effect of activity restrictions is greater.

#### Country-Level Control Variables

Finally, we include the *concentration* of the destination banking market, though we cannot predict the sign direction a priori. On the one hand, higher concentration could stimulate entry if it indicates higher returns; on the other hand, higher concentration could indicate the presence of implicit barriers to entry. Three dummy variables indicate whether a country is an *offshore* destination, is a *developing country* according to the income taxonomy of the *Worldbank*, or hosts a *financial center*.

The concentration results confirm our ambiguous theoretical expectations. Higher concentration in foreign banking markets increases the probability of foreign activity by German banks but lowers the volume. In our baseline specification, we find a negative sign for the offshore dummy, and splitting the sample according to banking group shows that this effect is driven by cooperative banks (see Table A.8). For the large banks, the offshore dummy reveals the expected positive sign. The signs for developing countries (negative) and financial centers (positive) match our expectations.

#### Marginal Effects

Marginal effects are presented in Table A.7. Because we use an ordered response model with discrete outcomes to model the *extensive* margin, the marginal effects differ across modes and indicate the extent of change in the probability of choosing one distinct mode in reaction to a change in a particular explanatory variable (at the mean). As we show in Table A.7, macroeconomic variables such as GDP and distance have key impacts on bank internationalization, and they are more important than many of the bank-level variables. In this sense, our results confirm previous literature for non-financial firms. The marginal effects for Mode 2a are insignificant because Modes 2a and 2b are very similar.

In summary, we find evidence of a productivity pecking order in international banking and an impact of bank-level risk on internationalization. Banks with less risk aversion appear more internationally oriented, though their volume of activity is lower, ceteris paribus. In addition, banks' foreign activities increase with market size, low information costs, and low entry barriers. The impact of macroeconomic volatility is not clear cut, which is consistent with the "correlation puzzle" (Aviat and Coeurdacier, 2007) in previous literature.

### 2.3.2 Robustness Tests

We perform several robustness tests based on the panel dimensions of our data and estimates of the model for different banking groups. These unreported results are available on request. The results consistently confirm the pecking order: The estimated cut-offs are significant and increase for more complex modes of foreign activity, the interval length relative to the productivity coefficient declines for more complex modes of activities, and productivity and size have positive and significant impacts.

**Panel Structure** We initially ignored the panel dimension of our dataset and pooled all observations across years, including time- and parent-fixed effects. Estimating the same model by year-by-year gives stable results for most variables, though particularly for those that we use to test the pecking order hypothesis. We also cluster the standard errors at the bank level, at the country level, and at the bank–country level. We bootstrapped the standard errors to consider productivity as a generated regressor. The findings are robust to these variations.

We also use a bank-country fixed effects panel for the *intensive* margin. The bank-specific productivity measure becomes insignificant, because there is relatively little within-sample variation in bank productivity, which is picked up by the fixed effects. The results for the size measure and the correction term do not change (both are positive and significant).

**Endogenous Regressors** We also run a test suggested by Semykina and Wooldridge (2010) to account for endogenous regressors in the primary equation (our *intensive* margin equation), as well as heterogeneously distributed and serially dependent error terms in the selection and primary equation. We adapt their method and estimate the *extensive* margin year-by-year while adding time averages of the bank-level variables. We compute the correction terms separately for each year and include them in the *intensive* margin equation. The productivity, core bank-level, and macro-level covariates preserve their significance and are qualitatively identical to those reported previously.

**Banking Groups** An objection to our analysis might note that we pool banks with different internationalization traditions. Therefore, we split the sample into the different banking groups: large, commercial, savings, and cooperative banks. The results in Table A.8 reveal similar findings for the country-level covariates; we already have alluded to the differences across banking groups.

Our focus on productivity and risk may ignore that smaller (savings and cooperative) banks might not be as active internationally, despite being highly productive, whether because they are legally prevented from operating abroad or because they have access to international markets through their head institutions (e.g., the "Landesbanken" for savings banks). Our results confirm this expectation only partly. That is, we find a similar pecking order for small and large banks in qualitative terms, but an increase in productivity has a much greater impact on both *extensive* and *intensive* margins for smaller than for larger banks. The only banking group for which productivity has a negative impact are commercial banks, which include private banks that often focus on specific segments of the German domestic banking market.

With regard to the risk results, we recognize that smaller banks might be different because, as an example, savings banks fall under public ownership and thus are covered by implicit or explicit state guarantees. However, our results do not confirm that the degree of risk aversion of publicly owned and privately owned banks exert systematically different impacts on internationalization patterns. If anything, more risk-averse, large banks appear more likely to enter foreign markets, though they engage in lower volumes of activities. For the remaining banking groups, risk features matter, but there is no clear link between the degree of risk aversion and the pattern of activities.

**OECD versus Non-OECD** Pooling across countries at different stages of development might affect our results. Therefore, we re-estimate the model for OECD countries only; the main results are similar, particularly with regard to the bank-level variables and productivity effects. The impact of country-level variables, such as market size and regulations, may differ slightly.

## 2.4 Conclusions

In this paper, we explore the source of heterogeneity across banks that determine whether banks expand abroad (the *extensive* margin) and the volume of their foreign activities (the *intensive* margin). We distinguish purely domestic banks, banks that hold international assets, banks with foreign branches, and banks with foreign subsidiaries *and* branches and model the *extensive* and *intensive* margins of foreign activity in the spirit of Heckman, using an ordered probit model for the selection equation. Our correction for selection explicitly accounts for the selection into different modes.

Our results show that heterogeneity in terms of bank-level productivity matters for international banking. Our main measure of productivity applies the model by Levinsohn and Petrin (2003) to the banking industry. We find that more complex and more costly modes of internationalization require greater productivity, so more productive banks tend to engage more internationally than do less productive banks, as well as hold higher international assets. Selection into foreign status therefore has a significant impact on the volume of activities. For banks (as for non-banks), gravity variables are critically important. Larger distances discourage international banking, larger and more developed markets promote international banking, and activity restrictions deter banks.

At the same time, risk factors at the bank level affect their foreign activities. More risk-averse banks are less likely to expand abroad, but they engage in larger volumes of activities. Risk factors at the country level also matter, but the signs of these effects do not always reflect theoretical expectations, which mirrors the correlation puzzle found in the previous literature. Another feature of the data pointing towards the importance of risk factors is that fact that small banks differ from small non-financial firms. Small, non-financial firms typically are domestically oriented and do not trade or engage in FDI, but smaller banks typically hold foreign assets in at least one market. This finding suggests the smaller fixed costs of holding international assets compared with selling or sourcing abroad. It also indicates that the motivation for internationalization differs, and portfolio considerations play an important role for banks.

Our study provides a first step towards the exploration of the *extensive* and *intensive* margins of international banking, and our results have implications for various research streams. In international finance and macroeconomics literature, it would be interesting to explore the extent to which adjustments according to the different margins may affect banks' responses to macroeconomic shocks and thus the persistence of shocks. Banking literature could extend our study by exploring how the endogenous sorting of banks into different modes of internationalization, as driven by bank productivity, affects the size distribution and productivity of the banking industry as a whole. Such an investigation ultimately would have implications for the ongoing discussion about the optimal regulation of banks, especially large banks. We leave these issues for further research.

## Contribution

Generally speaking, I was involved in all stages of creating this paper: collecting ideas, preparing the relevant data, interpreting results, writing and revising the text. This section provides details on my most central contribution which lies at the core of our paper, the empirical approach to reflect the productivity pecking order. In econometric terms, I have enriched the standard Heckman approach (see Heckman, 1979) with a hierarchical self-selection of banks into foreign market entry modes on the first stage. To the best of my knowledge, this approach is novel in the current literature.[18] An ordered probit model replaces the standard probit model on the first stage of the Heckman model.

Results on three empirical devices capture the productivity pecking order. First, as presented in section 2.2.2 and further elaborated in Appendix section A.1.2 the ordered probit model links the fixed cost of foreign market entry to the threshold parameter $\mu_k$. All estimated threshold parameters $\mu_k$ $(k = 1, 2a, 2b)$ are individually significant and indicate a hierarchy of fixed costs related to foreign market entry modes.

Second, estimated distances between two threshold parameters suit the intuitive differences in fixed costs of supplying banking services abroad. Foreign commercial presence requires higher fixed costs than cross-border banking. Hence, the productivity pecking order is reflected by equation 2.4 as the ratio of distance of adjacent threshold parameters relative to the estimated coefficient on the productivity measure.

Third, resulting threshold parameters $\hat{\mu}_k$ enter the second stage. Error terms on *extensive* and *intensive* margins are correlated which demands for a correction term on the *intensive* margin stage conditional on the entry mode on the *extensive* margin stage. The correction term thus varies by entry mode which introduces the hierarchy also on the *intensive* margin level. Our results confirm the significance of this correction term and hence the existence of a hierarchy in foreign entry modes and related fixed costs.

My procedure gives also way to interpret other estimated coefficients on the *extensive* margin stage in light of the self selection into different market entry modes. Equation 2.4 informs about the differences in fixed costs relative to the estimated coefficients and compares different foreign market entry modes. As opposed to that, it is also possible to

[18] Barattieri (2011) presents a similar model while using bilateral aggregates of trade flows and foreign direct investment. This paper, however, only came to our attention in 2011.

get an idea about the relative importance of two determinants of foreign market activity within one foreign market entry mode.

In short, my principal role was to develop and implement an empirical approach which captures the productivity pecking order in the estimation of *extensive* and *intensive* margins. Yet, the broader concept of the paper was derived jointly and writing was shared between the authors.

# Appendix A

# Margins of international banking

## A.1 Theoretical Appendix

### A.1.1 Theoretical Framework

To organize our thoughts of how bank productivity and bank risk preferences affect the internationalization, we apply a simple bank portfolio model to an international context. We assume that, in each period, the bank chooses its optimal portfolio structure, and the balance sheet restriction for bank i is given by:

$$W_i + D_i = L_i + L^*_{i,j} + R^*_i \tag{A.1}$$

where $W_i$= initial wealth, $D_i$= domestic deposits (liabilities), $L_i$= domestic loans (assets), $L^*_{i,j}$= foreign loans (assets) in country $j$, and $R^*_i$= risk-free assets.

To analyze the bank's choices, consider the profits earned from two modes of foreign activities. The expected profit of a domestic bank $i$ holding international assets in country $j$ depends on the returns on its domestic and international assets minus its variable costs and the fixed costs of foreign activities:

$$\begin{aligned} \Pi\left(1\right)_{ij} &= \left[r_L - c_{ij,L}\left(\omega_i\right)\right] L\left(1\right)_i \quad + \left[\left(1-\tau_j\right) r^*_{L,j} - c^*_{ij,L}\left(\omega_i\right)\right] L\left(1\right)^*_{ij} + r_F R\left(1\right)_i \\ &- \quad \left[r_D - c_{ij,D}\left(\omega_i\right)\right] D\left(1\right)_i - F\left(1\right)_j \end{aligned} \tag{A.2}$$

where $F(1)_j$ = the fixed costs of Mode 1; $r_L, r_D$= interest rates on (risky) assets and liabilities; $r_F$ = interest rate on the risk-free asset; $\tau_j$ = country-specific information costs that lower the return on international assets, with $0 < \tau_j < 1$ ; and $c_{ij,\bullet}$= variable costs. The (1) in this equation denotes the bank's profit function under Mode 1. The fixed and variable costs of international operations vary across host countries; we set the fixed costs of domestic operations to 0.

Both raising deposits and granting loans is costly for banks, and these costs reflect the resource inputs connected to handling loan applications, maintaining a branch network, or performing payment services. We assume that banks differ with regard to their productivity ($\omega_i$) and that more productive banks enjoy lower costs:

$$c_{ij,\bullet} = c_{ij,\bullet}(\varpi_i)\, with \frac{\partial c_{ij,\bullet}}{\partial \omega_i} < 0 \tag{A.3}$$

Each bank thus is characterized by a specific productivity level, which also transfers to its foreign affiliates. The costs of supplying financial services internationally are higher than those in the domestic context, such that $c_{ij,L}(\omega_i) < c^*_{ij,L}(\omega_i)$ , due to the institutional and regulatory differences across financial systems and lack of familiarity with the pool of foreign borrowers.

Therefore, the profits of a bank that establishes foreign affiliates (Mode 2) are:

$$\begin{aligned} \Pi(2)_{ij} &= [r_L - c_{ij,L}(\omega_i)]\, L(2)_i \quad + \left[r^*_{j,L} - c^*_{ij,L}(\omega_i)\right] L(2)^*_{ij} + r_F R(2)_i \\ &- \qquad [r_D - c_{ij,D}(\omega_i)]\, D(2)_i - F(2)_j \end{aligned} \tag{A.4}$$

This specification is similar to Equation (A.2) with two exceptions. First, we assume that the fixed costs of operating under Mode 2 are higher than the fixed costs of Mode 1, $F(1)_j < F(2)_j$ (see Cerutti et al., 2007). Second, information costs are lower under Mode 2, because the bank is operating in a foreign country. Without loss of generality, we set these costs to zero for Mode 2. Our specification thus involves a trade-off between the fixed and variable costs of foreign activities, similar to that known in trade literature.

The main difference between banks and non-financial firms is that the former care about the risk of their activities, so we follow Rochet (2008) and assume that the bank's objective function increases with expected profits and decreases with risk[1]:

$$U = U\left[E\left(\Pi_{ij}\right), \sigma^2\left(\Pi_{ij}\right)\right], \frac{\partial U}{\partial E\left(\Pi_{ij}\right)} > 0, \frac{\partial U}{\partial \sigma^2\left(\Pi_{ij}\right)} < 0 \tag{A.5}$$

With the simplifying assumption that deposits carry no risk, the variance of the portfolio can be given by $\sigma^2\left(\Pi_{ij}\right) = L_i^2\sigma^2 + L_{ij}^{*2}\sigma_j^{*2} + 2L_iL_{ij}^*COV_j$ , where $\sigma^2\left(\sigma_j^{*2}\right)$ is the country-specific risk of domestic (foreign) assets, and $COV_j$ is the covariance matrix of domestic and foreign returns.

We use this model to analyze the *intensive* and *extensive* margins of banks' foreign activities[2]. For the extensive margin, the bank chooses to be active in the foreign country if its expected utility is positive, that is, if $U > 0$ holds. Using Equations (A.3)-(A.5), it is straightforward to show that the probability of investing abroad is higher with (1) lower fixed costs of foreign activity ($F_j$), (2) lower information costs ($\tau_j$), (3) higher bank productivity ($\omega_i$) and (4) lower risk of foreign activities ($\sigma_j^{*2}$). Moreover, banks prefer Mode 2 over Mode 1 if their productivity exceeds a threshold ($\overline{\omega}$) – such that banks with $\omega_i < \overline{\omega}$ choose Mode 1, but banks with $\omega_i > \overline{\omega}$ choose Mode 2 and maintain affiliates abroad – and if the savings in the fixed costs associated with entering through Mode 2 are small relative to the higher variable costs under Mode 1. The volume of international activities, the *intensive* margin, can be analyzed by differentiating the objective function with respect to the volume of international risky assets ($L_{ij}^*$)[3]:

$$\frac{\partial U}{\partial L_{ij}^*} = \frac{\partial U}{\partial E\left(\Pi_{ij}\right)}\left[\left(1-\tau_j\right)r_{L,j}^* - c_{ij,L}^*\left(\omega_i\right)\right] + 2\frac{\partial U}{\partial \sigma^2\left(\Pi_{ij}\right)}\left[L_{ij}^*\sigma_j^{*2} + L_iCOV_j\right] = 0 \tag{A.6}$$

By denoting the degree of the bank's risk aversion,

$$\lambda_i = -\frac{1}{2}\frac{\partial U}{\partial E\left(\Pi_{ij}\right)}\frac{\partial \sigma^2\left(\Pi_{ij}\right)}{\partial U} > 0 \tag{A.7}$$

we can rewrite the first-order condition from Equation (A.6) as

[1] This specification holds under certain assumptions in an incomplete markets setting; see Rochet (2008).

[2] We summarize the results of the comparative static analysis in Table B.1

[3] The qualitative results are the same for the different modes; therefore, we drop the indices.

$$\frac{\partial U}{\partial L_{ij}^*} = \frac{\partial U}{\partial E\left(\Pi_{ij}\right)} \left\{ \left(1-\tau_j\right) r_{L,j}^* - c_{ij,L}^*\left(\omega_i\right) - \frac{1}{\lambda_i}\left[L_{ij}^*\sigma_j^{*2} + L_i COV_j\right] \right\} = 0 \tag{A.8}$$

With Equation (A.8), we obtain comparative static results that demonstrate which banks will increase the volume of their international assets when they experience higher gross returns ($r_L^*$), lower information costs ($\tau_j$), higher productivity and thus lower variable costs $\left(c_{ij,L}^*\left(\omega_i\right)\right)$, lower risk $\left(\sigma_j^{*2}\right)$, lower correlations between domestic and foreign returns (lower $COV_j$ ), and lower degrees of risk aversion ($\lambda_i$).

### A.1.2 Deriving the Correction Term

Deriving the correction term requires us to draw on the standard bivariate normality of error terms in equations that describe the *extensive* and *intensive* margins. The starting point is equation 2.1

$$\begin{aligned} E\left[IM_{ijt} \mid Z_{ijt}, EM_{ijt}=k\right] &= \alpha X_{ijt} + \underbrace{\sigma_{IM} E\left[u_{ijt} \mid Z_{ijt}, EM_{ijt}=k\right]} \\ & \quad where \qquad k = 1, 2a, 2b \end{aligned} \tag{A.9}$$

We next focus on the conditional expectations of the error term:

$$\sigma_{IM} E\left[u_{ijt} \mid Z_{ijt}, EM_{ijt}=k\right]$$

Assuming that the errors of the *extensive* and *intensive* margin are correlated, we can restate this term as $\sigma_{IM} E\left[\rho v_{ijt} \mid Z_{ijt}, EM_{ijt}=k\right]$ . We can further simplify the conditioning part to obtain $\sigma_{IM}\rho E\left[v_{ijt} \mid \mu_k - \beta Z_{ijt} < v_{ijt} < \mu_{k+1} - \beta Z_{ijt}\right]$.

If we assume the error term $v_{ijt}$ follows a conditional standard normal distribution, we can explicitly write the conditional expectation as:

$$\begin{aligned} E \quad & \left[v_{ijt} \mid \mu_k - \beta Z_{ijt} < v_{ijt} < \mu_{k+1} - \beta Z_{ijt}\right] \\ = \quad & \int_{\mu_k - \beta Z_{ijt}}^{\mu_{k+1} - \beta Z_{ijt}} v_{ijt} f \left(v_{ijt} \mid \mu_k - \beta Z_{ijt} < v_{ijt} < \mu_{k+1} - \beta Z_{ijt}\right) dv_{ijt} \end{aligned} \tag{A.10}$$

Next, rewriting the conditional expectation while applying the definition of a conditional density function yields a ratio of the density $\underline{\phi\left(v_{ijt}\right)}$ and the cumulative density function, such that we can rewrite Equation A.10 as:

$$= \frac{1}{\Phi\left(\mu_{k+1}-\beta Z_{ijt}\right)-\Phi\left(\mu_k-\beta Z_{ijt}\right)} \int\limits_{\mu_k-\beta Z_{ijt}}^{\mu_{k+1}-\beta Z_{ijt}} v_{ijt}\phi\left(v_{ijt}\right)dv_{ijt} \tag{A.11}$$

Now, it is possible to integrate and exploit the fact that $\phi'\left(v_{ijt}\right) = -v_{ijt}\phi\left(v_{ijt}\right)$:

$$\begin{aligned} &= \frac{-\phi\left(\mu_{k+1}-\beta Z_{ijt}\right)-\left(-\phi\left(\mu_{k+1}-\beta Z_{ijt}\right)\right)}{\Phi\left(\mu_{k+1}-\beta Z_{ijt}\right)-\Phi\left(\mu_k-\beta Z_{ijt}\right)} \\ &= \frac{\phi\left(\mu_k-\beta Z_{ijt}\right)-\phi\left(\mu_{k+1}-\beta Z_{ijt}\right)}{\Phi\left(\mu_{k+1}-\beta Z_{ijt}\right)-\Phi\left(\mu_k-\beta Z_{ijt}\right)} \end{aligned} \tag{A.12}$$

In turn, we obtain three distinct correction terms $\lambda^k_{OP}$ to address the selection bias. Their particular shape and conditionality on the realized modes (categories 0, 1, 2a, or 2b) of the extensive margin level distinguish our ordered probit model from Heckman's (1979) conventional selection equation. The conditional error term of the *intensive* margin $\sigma_{IM}E\left[\rho v_{ijt} \mid Z_{ijt}, EM_{ijt}=k\right]$ transforms into:

$$\sigma_{IM}\rho\lambda^1_{ijt} = \sigma_{IM}\rho\tfrac{\phi(\mu_1-\beta Z_{ijt})-\phi(\mu_{2a}-\beta Z_{ijt})}{\Phi(\mu_{2a}-\beta Z_{ijt})-\Phi(\mu_1-\beta Z_{ijt})} \qquad if\ EM_{ijt}=1$$
$$(cross-border)$$

$$\sigma_{IM}\rho\lambda^{2a}_{ijt} = \sigma_{IM}\rho\tfrac{\phi(\mu_{2a}-\beta Z_{ijt})-\phi(\mu_{2b}-\beta Z_{ijt})}{\Phi(\mu_{2b}-\beta Z_{ijt})-\Phi(\mu_{2a}-\beta Z_{ijt})} \qquad if\ EM_{ijt}=2a$$
$$(cross-border\ and\ branches)$$

$$\sigma_{IM}\rho\lambda^{2b}_{ijt} = \sigma_{IM}\rho\tfrac{\phi(\mu_{2b}-\beta Z_{ijt})}{1-\Phi(\mu_{2b}-\beta Z_{ijt})} \qquad if\ EM_{ijt}=2b$$
$$(cross-border, branches\ and\ subsidiaries)$$

which results in the correction term. In the equation for the *intensive* margin, $\sigma_{IM}\rho$

becomes part of the coefficient to estimate, whereas the regressor $\lambda^k_{ijt}$ carries information on the different cut-offs that characterize the extensive margin.

### A.1.3 Estimating Bank Productivity

We estimate a baseline productivity measure using a model of bank production in line withNakane and Weintraub (2005) and Martín-Oliver and Salas-Fumás (2008). Thereby, our results are easier to compare with literature investigating non-financial multinational firms (e.g., Greenaway et al., 2007). We prefer the parsimonious measure of productivity that focuses on the volume of financial services provided and include covariates to control separately and more explicitly for the risk characteristics of banks, captured by CAMEL variables (i.e., capitalization, asset quality, managerial skill, earnings, and liquidity).

Banks are intermediaries between savers and investors (Martín-Oliver and Salas-Fumás, 2008), so the aggregate lending volume of a bank is specified as its output (Nakane and Weintraub, 2005). The first input variable is the sum of deposits and other debt liabilities. The second input is bank staff. In addition, banks must have physical facilities, such as branches and offices, as well as IT and back-office infrastructures, to provide loans. Because these variables cannot be adjusted quickly, we include fixed assets as a state variable.

Unbiased estimation of bank productivity requires the specification of intermediate inputs that are informative regarding productivity and influence output through their impacts on factor accumulation. Levinsohn and Petrin (2003) suggest specifying intermediate inputs, such as materials or electricity subtracted from gross value added, that contribute to the production process and depend on productivity. For banks, equity capital can fulfill the key requirements of such an intermediate input. It is rarely used to fund loans (Mester, 1997), but it indicates a bank's risk-taking to markets and regulators (Berger, 1995) and thus determines funding costs and demand. Because determining optimal levels of (costly) equity capital under regulatory constraints is a key task of bankers, it should correlate with bank productivity.

We estimate bank productivity using a production function approach (Levinsohn and Petrin, 2003). Consider a log-linear Cobb-Douglas production function for bank $i$ in year $t$:

$$lnY_{it} = \beta_0 + \beta_X lnX_{it} + \beta_K lnK_{it} + \beta_Z lnZ_{it} + \omega_{it} + \eta_{it} \tag{A.13}$$

(A.11) Bank output is denoted as $Y_{it}$, variable input factors by $X_{it}$, production factors that are fixed in the short-run by $K_{it}$, and intermediate inputs required in the production process as $Z_{it}$. Of the two error components, $\omega_{it}$ denotes unobservable productivity, and is a random error term uncorrelated with banks' input choices. Although widely discussed in empirical literature on production functions, this issue has been virtually neglected in bank productivity studies (cf. Nakane and Weintraub, 2005). Banks that experience a positive productivity shock expand their production, which increases their input demand. A negative productivity shock instead reduces their input demand. Interdependency in factor choices and (unobservable) productivity creates biased estimates of $\omega_{it}$ (Levinsohn and Petrin, 2003), which indicates productivity is a state variable that influences a bank's input decision, leading to simultaneity problems when estimating production functions. The same problem arises for their dual functions, that is, the cost and profit optimization problems.

We use the program provided by Petrin et al. (2004) to implement the Levinsohn and Petrin (2003) estimator of productivity and refer to them and the Discussion Paper versions of this paper for further details.

## A.2 Data Appendix

We obtained all bank data from unconsolidated balance sheets, profit and loss accounts, and audit reports reported annually by all banks to the German central bank (*Deutsche Bundesbank*). The variables for both the productivity estimation and the CAMEL vector are corrected for outliers by truncating at the 1st and 99th percentiles, respectively. Level variables are deflated by the consumer price index. The country-specific variables come from the various sources indicated next.

**Bank-level variables**

**Borrowed funds** Sum of deposits and other debt liabilities in EUR millions.

**Capitalization** Core capital as a percentage of gross total assets.

**Cost-to-income ratio** Personnel expenditure as a percentage of total administrative cost.

**Employees** Full-time equivalents.

**Equity** Gross total equity in EUR millions.

**Lending** Total customer loans in EUR millions.

**Loan-loss provisions** Stock of loan-loss provisions as a percentage of gross total loans.

**Non-performing loans** Loans with latent risks according to central bank auditors as a percentage of total audited loans.

**Physical capital** Fixed assets including IT capital stock in EUR millions.

**Productivity** From Levinsohn and Petrin (2003), estimates of bank productivity.

**Reserves** Hidden reserves according to §340f of the German commercial code as a percentage of gross total assets.

**Return on equity (ROE)** Operating results, including net interest, fees, commissions, and trading income as a percentage of equity capital.

**Total assets** Gross total assets.

**Definition of banking groups** Large banks represent the head institutions of the savings ("Landesbanken") and the cooperative banking sectors, as well as the largest commercial banks. Commercial banks are privately owned but not necessarily publicly listed banks. Savings banks are (local) government-owned regional banks. Cooperative banks are mutually owned regional banks.

**Country-level variables**

**Activity restrictions** Whether banks are restricted from engaging in securities underwriting, insurance underwriting and selling, real estate investments, management, and development. Higher values indicate more restrictions (Source: Beck et al., 2006).

**Concentration** Fraction of total assets held by the three largest banks in the economy (Source: World Bank).

**Capital regulation** Combined measure of overall and initial capital stringency, ranging from 0 to 9, with a higher value indicating greater stringency (Source: Beck et al., 2006).

**Developing country** Indicator variable equal to 1 if the country is not a high-income country, according to the income taxonomy of the Worldbank (Source: WDI, Worldbank).

**Distance** Geographic distance between Germany and host country $j$ (Source: CEPII, Paris).

**Economic freedom** Composite of 10 factors measuring institutional quality and policies pertaining to trade, government finances, government interventions, monetary policy, capital flows and foreign investment, banking and finance, wages and prices, property rights, regulation, and black market activity; higher values indicate better institutions (Source: Beck et al., 2006).

**FDI** Aggregate volume of FDI in host country (Source: Microdatabase Foreign Direct Investment (MiDi), *Deutsche Bundesbank*).

**Financial center** Indicator variable equal to 1 for Luxembourg, Switzerland, and the UK, including the Channel Islands, following the definition of the "External Position Report" (Source: *Deutsche Bundesbank*).

**GDP per capita** Gross domestic product in USD millions (2000 = 100).

**GDP–growth correlations** Correlation of German and destination country GDP in the preceding five years.

**Institutional quality** Six dimensions of indices: voice and accountability, government effectiveness, political stability, regulatory quality, rule of law, and control of corruption (Beck et al., 2006).

**Offshore destination** Indicator variable equal to 1 for Hong Kong, Singapore, and the Philippines, following the definition of the "External Position Report" (Source: *Deutsche Bundesbank*).

**Volatility** Change of growth rate residuals, net of cyclical effects in the preceding five-year period.

**External Position Report**

Data about the international assets of German banks come from the "External Position Report" ("Auslandsstatus") of the *Deutsche Bundesbank*. They are confidential and can be used on the premises of the *Deutsche Bundesbank* only.

**International assets** Loans and advances to banks, companies, governments, bonds and notes, foreign shares and other equity, participation abroad, denominated or converted into euro.

**Branches and subsidiaries** Foreign affiliates of German parent banks. Branches do not enjoy independent legal status, whereas subsidiaries do. Assets held by affiliates are attributed to the country in which they are located.

**List of countries** United Arab Emirates, Argentina, Austria, Australia, Belgium, Bulgaria, Brazil, Canada, Switzerland, Chile, China, Cyprus, Czech Republic, Denmark, Estonia, Egypt, Spain, Finland, France, Greece, Hong Kong, Hungary, Indonesia, Ireland, Israel, India, Italy, Japan, South Korea, Cayman Islands, Lithuania, Luxemburg, Latvia, Morocco, Malta, Mexico, Malaysia, Netherlands, Norway, New Zealand, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Sweden, Singapore, Slovenia, Slovakia, Thailand, Turkey, Taiwan, Ukraine, United Kingdom, United States, Vietnam, South Africa.

# A.3 Tables and Figures

Table A.1: Theoretical Predictions and Measurements

| Parameter | Measurement | Expected Signs<br>Extensive margin | Intensive Margin | Mode2 $\succsim$Mode1? |
|---|---|---|---|---|
| **Bank level** | | | | |
| Bank productivity | Productivity, cost-to-income ratio, return on equity, size | + | + | + |
| Bank risk aversion | High risk aversion: Capitalization, reserves, loan-loss provisions Low risk aversion: Non-performing loans | — | — | — |
| **Country level** | | | | |
| Fixed costs of foreign activity | Activity restrictions, capital restrictions | — | 0 | — |
| Expected returns | GDP, GDP per capita, German FDI | + | + | + |
| Information costs | Distance, institutional quality | — | — | + |
| Country risk | GDP growth volatility | — | — | — |
| Return correlations | Correlation between domestic and foreign GDP growth | — | — | — |

Table A.2: Descriptive Statistics: Bank Productivity Estimates

| Variable | | Mean | S.d. | Percentiles 1st | 50th | 99th |
|---|---|---|---|---|---|---|
| Lending | Y | 1,333.6 | 11,666.6 | 5.1 | 197.4 | 18,939.7 |
| Borrowed funds | X1 | 1,257.9 | 10,329.0 | 5.9 | 233.7 | 13,023.9 |
| Employees | X2 | 270.6 | 1,188.4 | 5.4 | 92.0 | 2,593.0 |
| Equity | Z | 106.0 | 722.0 | 1.3 | 19.2 | 1,506.1 |
| Physical capital | K | 14.9 | 56.1 | 0.1 | 5.1 | 140.6 |

Notes: In Table A.2, the data are based on 12,569 observations for 2,439 banks between 2000 and 2006. All monetary volumes are in EUR millions. Employees are full-time equivalents. Borrowed funds are the sum of deposits and other debt liabilities.

Table A.3: Production Function Estimates

| | Levinsohn-Petrin | | | OLS | | |
|---|---|---|---|---|---|---|
| | Coefficient | S.d. | p-value | Coefficient | S.d. | p-value |
| ln Employees | 0.176 | 0.049 | 0.000 | 0.577 | 0.010 | 0.000 |
| ln Borrowed funds | 0.404 | 0.067 | 0.000 | 0.526 | 0.007 | 0.000 |
| ln Physical capital | 0.240 | 0.032 | 0.000 | -0.035 | 0.007 | 0.000 |
| Constant | | | | -0.129 | 0.030 | 0.000 |
| | *$Chi^2$* | *p-value* | *F-test* | *p-value* | | |
| $H_0 = \beta_1 + \beta_2 + \beta_3 = 1$ | 17.4 | 0.000 | 345.8 | 0.000 | | |
| $R^2$ | | | 0.597 | | | |

Notes: In Table A.3, estimates are based on 12,569 bank–year observations for the years 2000–2006. Time-specific fixed effects are included but not reported. Bootstrapped standard errors are reported for estimates, following Levinsohn and Petrin (2003); OLS estimates are based on robust standard errors.

Table A.4: CAMEL Profile and Productivity by Internationalization Mode

| | Domestic | | International assets | | Foreign branches | | Subsidiaries | | All banks | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.d. | Mean | S.d. | Mean | S.d. | Mean | S.d. | Mean | S.d. |
| Capitalization | 5.85 | 3.11 | 5.42 | 2.62 | 4.10 | 3.40 | 3.78 | 4.46 | 5.76 | 3.02 |
| Cost-income ratio | 44.10 | 9.17 | 41.07 | 10.56 | 25.65 | 14.69 | 26.23 | 12.09 | 43.45 | 9.58 |
| Hidden reserves | 1.41 | 1.04 | 1.34 | 1.05 | 0.17 | 0.29 | 0.16 | 0.24 | 1.39 | 1.04 |
| Loan-loss provisions | 5.40 | 7.83 | 5.17 | 10.61 | 2.94 | 4.20 | 2.54 | 2.88 | 5.35 | 8.46 |
| Non-performing loans | 0.96 | 1.21 | 0.97 | 1.03 | 0.81 | 0.86 | 0.66 | 0.61 | 0.96 | 1.18 |
| Productivity | 11.78 | 25.63 | 19.66 | 33.99 | 115.53 | 60.76 | 112.29 | 61.60 | 13.56 | 28.13 |
| Return on Equity | 10.52 | 16.32 | 10.98 | 14.58 | 7.50 | 17.76 | 5.69 | 14.63 | 10.61 | 15.98 |

Notes: Descriptive statistics of parent bank-specific variables, measured in percentages except for productivity. Parent banks are sorted by their mode of internationalization: Mode 1 (International assets), Mode 2a (Foreign branches), and Mode 2b (Branches and subsidiaries). Variable definitions appear in the Data Appendix.

Table A.5: Country-Specific Variables

| Variable | Unit | Mean | S.d. | Percentiles 1st | Percentiles 99th | N |
|---|---|---|---|---|---|---|
| Activity restrictions | Score | 8.89 | 2.53 | 4.00 | 14.00 | 174 |
| Capital regulation | Score | 5.50 | 1.55 | 2.00 | 8.00 | 174 |
| Concentration of banking market | % | 64.24 | 20.54 | 22.73 | 99.32 | 304 |
| Developing destination | 0/1 indicator | 0.52 | 0.50 | 0.00 | 1.00 | 304 |
| Distance | Kilometers | 4.92 | 4.55 | 0.28 | 18.12 | 304 |
| Financial center destination | 0/1 indicator | 0.05 | 0.22 | 0.00 | 1.00 | 304 |
| Foreign direct investment (FDI) | Bn EUR | 11.60 | 30.90 | 0.01 | 212.00 | 304 |
| GDP growth correlations | % | 35.44 | 49.63 | -80.33 | 98.79 | 304 |
| Gross domestic product (GDP) | Bn USD | 597.00 | 1,610.00 | 5.25 | 10,900.00 | 304 |
| Institutional quality | Score | 3.53 | 0.52 | 2.18 | 4.50 | 174 |
| Offshore destination | 0/1 indicator | 0.05 | 0.22 | 0.00 | 1.00 | 304 |
| GDP per capita (log) | Tsd USD | 16.54 | 16.71 | 0.57 | 71.87 | 304 |
| Volatility of foreign GDP | % | 1.91 | 1.58 | 0.36 | 7.74 | 304 |

Table A.6: Baseline Estimation Results

| | Extensive Margin | | | | Intensive Margin | | | |
|---|---|---|---|---|---|---|---|---|
| | Productivity | Micro | Macro | Regulation | Productivity | Micro | Macro | Regulation |
| **Productivity and selection** | | | | | | | | |
| Correction term | | | | | 3.9406*** | -0.4161*** | 0.2836*** | 0.5669*** |
| | | | | | (0.0548) | (0.0397) | (0.0301) | (0.0372) |
| Productivity | 0.0048*** | 0.0004*** | 0.0006*** | 0.0005*** | 0.0346*** | 0.0128*** | 0.0146*** | 0.0155*** |
| | (0.0000) | (0.0001) | (0.0001) | (0.0001) | (0.0003) | (0.0003) | (0.0003) | (0.0003) |
| Size | | 0.2791*** | 0.4124*** | 0.4356*** | | 0.1862*** | 0.4252*** | 0.5262*** |
| | | (0.0019) | (0.0024) | (0.0030) | | (0.0107) | (0.0099) | (0.0116) |
| **Bank-specific variables** | | | | | | | | |
| Cost-income ratio | | 0.0047*** | 0.0069*** | 0.0071*** | | -0.0598*** | -0.0591*** | -0.0561*** |
| | | (0.0003) | (0.0003) | (0.0004) | | (0.0011) | (0.0011) | (0.0013) |
| Return on equity | | 0.0015*** | 0.0021*** | 0.0016*** | | -0.0003 | 0.0011* | 0.0017** |
| | | (0.0002) | (0.0002) | (0.0002) | | (0.0007) | (0.0006) | (0.0008) |
| Capitalization | | -0.0129*** | -0.0185*** | -0.0188*** | | 0.0279*** | 0.0195*** | 0.0212*** |
| | | (0.0008) | (0.0010) | (0.0012) | | (0.0035) | (0.0033) | (0.0038) |
| Hidden reserves | | -0.0068*** | -0.0131*** | -0.0095*** | | -0.1803*** | -0.2281*** | -0.2346*** |
| | | (0.0022) | (0.0026) | (0.0032) | | (0.0089) | (0.0084) | (0.0098) |
| Non-performing loans | | 0.0053** | 0.0061** | 0.0035 | | -0.1177*** | -0.1006*** | -0.0805*** |
| | | (0.0023) | (0.0027) | (0.0033) | | (0.0114) | (0.0108) | (0.0125) |
| Loan-loss provisions | | -0.0005* | -0.0004 | -0.0002 | | 0.0143*** | 0.0147*** | 0.0131*** |
| | | (0.0002) | (0.0003) | (0.0003) | | (0.0010) | (0.0009) | (0.0011) |
| **Country-specific variables** | | | | | | | | |
| Gross domestic product (GDP) | | | 0.1833*** | 0.1980*** | | | -0.4378*** | -1.0102*** |
| | | | (0.0028) | (0.0054) | | | (0.0112) | (0.0212) |
| GDP per capita | | | 0.3570*** | 0.1343*** | | | -0.1860*** | 0.6595*** |
| | | | (0.0046) | (0.0094) | | | (0.0206) | (0.0438) |
| German FDI | | | 0.1996*** | 0.2881*** | | | 0.7133*** | 0.9179*** |
| | | | (0.0026) | (0.0042) | | | (0.0114) | (0.0165) |
| Growth correlations | | | 0.2469*** | 0.1278*** | | | -0.0526* | -0.0247 |
| | | | (0.0066) | (0.0099) | | | (0.0290) | (0.0388) |
| Growth volatility | | | -0.0074*** | -0.0740*** | | | 0.1523*** | 0.1303*** |
| | | | (0.0019) | (0.0026) | | | (0.0084) | (0.0122) |
| Distance | | | -0.1757*** | -0.3426*** | | | 0.1656*** | 0.3885*** |
| | | | (0.0029) | (0.0043) | | | (0.0119) | (0.0172) |
| Concentration | | | 0.6128*** | 0.1565*** | | | -1.6782*** | -3.9171*** |
| | | | (0.0135) | (0.0211) | | | (0.0502) | (0.0825) |
| Activity restrictions | | | | -0.0876*** | | | | 0.0244*** |
| | | | | (0.0019) | | | | (0.0070) |
| Capital restrictions | | | | -0.1109*** | | | | 0.0361*** |
| | | | | (0.0021) | | | | (0.0078) |
| Institutional quality | | | | 0.0096 | | | | -0.2245*** |
| | | | | (0.0142) | | | | (0.0565) |
| **Intercepts and fixed effects** | | | | | | | | |
| East German banks | | -0.2115*** | -0.3270*** | -0.3510*** | | 0.7536*** | 0.6434*** | 0.4145*** |
| | | (0.0072) | (0.0087) | (0.0108) | | (0.0326) | (0.0308) | (0.0357) |
| Large banks | | 1.6847*** | 2.3272*** | 2.3492*** | | | | |
| | | (0.0204) | (0.0232) | (0.0319) | | | | |
| Commercial banks | | 0.2607*** | 0.4064*** | 0.3578*** | | | | |
| | | (0.0084) | (0.0097) | (0.0125) | | | | |
| Savings banks | | -0.1059*** | -0.1421*** | -0.1628*** | | | | |
| | | (0.0057) | (0.0068) | (0.0086) | | | | |
| Euro Area | | 0.8850*** | -0.1416*** | -0.4961*** | | 1.9278*** | 1.7396*** | 2.2315*** |
| | | (0.0047) | (0.0063) | (0.0095) | | (0.0305) | (0.0214) | (0.0359) |
| Offshore destination | | | -0.3893*** | -0.1526*** | | | -0.9356*** | -0.7185*** |
| | | | (0.0147) | (0.0192) | | | (0.0684) | (0.0912) |
| Developing destination | | | -0.3778*** | -0.3885*** | | | 0.1888*** | -1.0713*** |
| | | | (0.0106) | (0.0194) | | | (0.0501) | (0.0943) |
| Financial center destination | | | 0.8502*** | 0.3274*** | | | 0.3207*** | 1.1554*** |
| | | | (0.0106) | (0.0159) | | | (0.0290) | (0.0414) |
| Constant | | | | | -1.2847*** | 5.8681*** | 6.6187*** | 10.5808*** |
| | | | | | (0.0788) | (0.1010) | (0.3484) | (0.5585) |
| Cut-off 1 | 0.8998*** | 2.0056*** | 12.4399*** | 8.7965*** | | | | |
| | (0.0019) | (0.0172) | (0.0638) | (0.1201) | | | | |
| Cut-off 2 | 3.0711*** | 4.6935*** | 16.0496*** | 12.7090*** | | | | |
| | (0.0103) | (0.0226) | (0.0683) | (0.1230) | | | | |
| Cut-off 3 | 3.3637*** | 5.0845*** | 16.4922*** | 13.2597*** | | | | |
| | (0.0149) | (0.0267) | (0.0700) | (0.1253) | | | | |
| **Observations and diagnostics** | | | | | | | | |
| Observations | 632,835 | 618,786 | 608,964 | 343,770 | 128,745 | 126,964 | 126,885 | 94,329 |
| McFadden $R^2$ | 0.0133 | 0.1347 | 0.4028 | 0.4125 | 0.1015 | 0.2096 | 0.2922 | 0.2893 |
| F-tests: All equal to zero | | 86,490 | 256,636 | 170,327 | | 2,246 | 2,096 | 1,372 |
| Micro | | 25,434 | 35,476 | 24,818 | | 619.6 | 995.2 | 798.5 |
| Macro | | | 114,927 | 63,585 | | | 1,419 | 938.4 |
| Regulation | | | | 5,299 | | | | 16.27 |
| Banking groups | | 8,648 | 12,732 | 6,942 | | | | |

Notes: The selection equation (Extensive Margin) is estimated as an ordered probit model and includes unreported dummies for banking groups as exclusion restrictions. The dependent variable is the mode of foreign activities. The primary equation (Intensive Margin) is estimated with OLS. The dependent variable is the log volume of international assets. Standard errors are in brackets, and time-fixed effects are included but not reported. Productivity is obtained by the method proposed by Levinsohn and Petrin 2003. For further variable descriptions, see the Data Appendix. ***Significant at 1% level. **Significant at 5% level. * Significant at 10% level.

Table A.7: Marginal Effects

| | Extensive Margin | | | | | Intensive Margin | |
|---|---|---|---|---|---|---|---|
| | $\beta$ | $dlny/\delta lnx_{m=0}$ | $dlny/\delta lnx_{m=1}$ | $dlny/\delta lnx_{m=2a}$ | $dlny/\delta lnx_{m=2b}$ | $\beta$ | $dlny/\delta lnx$ |
| **Productivity and selection** | | | | | | | |
| Correction term | | | | | | 0.5669*** | 0.0823*** |
| | | | | | | (0.0372) | (0.0054) |
| Productivity | 0.0005*** | -0.0020*** | 0.0101*** | 0.0341 | 0.0379*** | 0.0155*** | 0.0614*** |
| | (0.0001) | (0.0004) | (0.0020) | (0.0731) | (0.0074) | (0.0003) | (0.0013) |
| Size | 0.4356*** | -0.3911*** | 1.9687*** | 6.6097 | 7.3497*** | 0.5262*** | 0.3958*** |
| | (0.0030) | (0.0028) | (0.0150) | (14.1391) | (0.0692) | (0.0116) | (0.0087) |
| **Bank-specific variables** | | | | | | | |
| Cost-income ratio | 0.0071*** | -0.0922*** | 0.4643*** | 1.559 | 1.7335*** | -0.0561*** | -0.4837*** |
| | (0.0004) | (0.0055) | (0.0275) | (3.3237) | (0.1034) | (0.0013) | (0.0109) |
| Return on equity | 0.0016*** | -0.0051*** | 0.0258*** | 0.0867 | 0.0965*** | 0.0017** | 0.0039** |
| | (0.0002) | (0.0007) | (0.0036) | (0.1858) | (0.0133) | (0.0008) | (0.0017) |
| Capitalization | -0.0188*** | 0.0324*** | -0.1629*** | -0.5469 | -0.6081*** | 0.0212*** | 0.0240*** |
| | (0.0012) | (0.0021) | (0.0104) | (1.1718) | (0.0390) | (0.0038) | (0.0043) |
| Hidden reserves | -0.0095*** | 0.0039*** | -0.0198*** | -0.0665 | -0.0740*** | -0.2346*** | -0.0659*** |
| | (0.0032) | (0.0013) | (0.0068) | (0.1445) | (0.0253) | (0.0098) | (0.0027) |
| Non-performing loans | 0,0035 | -0,001 | 0,0051 | 0.017 | 0,0189 | -0.0805*** | -0.0163*** |
| | (0.0033) | (0.0010) | (0.0048) | (0.0398) | (0.0179) | (0.0125) | (0.0025) |
| Loan-loss provisions | -0,0002 | 0,0004 | -0,0018 | -0.006 | -0,0067 | 0.0131*** | 0.0142*** |
| | (0.0003) | (0.0005) | (0.0028) | (0.0160) | (0.0103) | (0.0011) | (0.0012) |
| **Country-specific variables** | | | | | | | |
| Gross domestic product (GDP) | 0.1980*** | -1.5465*** | 7.7850*** | 26.1368 | 29.0633*** | -1.0102*** | -5.6980*** |
| | (0.0054) | (0.0429) | (0.2141) | (55.4173) | (0.8149) | (0.0212) | (0.1202) |
| GDP per capita | 0.1343*** | -0.3716*** | 1.8706*** | 6.2803 | 6.9835*** | 0.6595*** | 1.3861*** |
| | (0.0094) | (0.0260) | (0.1310) | (13.3213) | (0.4903) | (0.0438) | (0.0921) |
| German FDI | 0.2881*** | -1.2747*** | 6.4166*** | 21.5428 | 23.9548*** | 0.9179*** | 3.1511*** |
| | (0.0042) | (0.0181) | (0.0974) | (46.2447) | (0.3836) | (0.0165) | (0.0571) |
| Growth correlations | 0.1278*** | -0.0155*** | 0.0781*** | 0.2621 | 0.2915*** | -0.0247 | -0.0033 |
| | (0.0099) | (0.0012) | (0.0061) | (0.5598) | (0.0227) | (0.0388) | (0.0052) |
| Growth volatility | -0.0740*** | 0.0436*** | -0.2194*** | -0.7366 | -0.8191*** | 0.1303*** | 0.0392*** |
| | (0.0026) | (0.0016) | (0.0077) | (1.5826) | (0.0292) | (0.0122) | (0.0037) |
| Distance | -0.3426*** | 0.8283*** | -4.1697*** | -13.9991 | -15.5666*** | 0.3885*** | 0.5976*** |
| | (0.0043) | (0.0110) | (0.0533) | (29.9672) | (0.2166) | (0.0172) | (0.0265) |
| Concentration | 0.1565*** | -0.0308*** | 0.1552*** | 0.5209 | 0.5793*** | -3.9171*** | -0.5304*** |
| | (0.0211) | (0.0041) | (0.0210) | (1.0798) | (0.0782) | (0.0825) | (0.0112) |
| Activity restrictions | -0.0876*** | 0.2323*** | -1.1693*** | -3.9257 | -4.3652*** | 2.2315*** | 0.1565*** |
| | (0.0019) | (0.0051) | (0.0257) | (8.3913) | (0.0987) | (0.0359) | (0.0025) |
| Capital restrictions | -0.1109*** | 0.1815*** | -0.9136*** | -3.0672 | -3.4106*** | 0.0244*** | 0.0400*** |
| | (0.0021) | (0.0034) | (0.0174) | (6.5596) | (0.0675) | (0.0070) | (0.0115) |
| Institutional quality | 0.0096 | -0.0101 | 0.0507 | 0.1703 | 0.1894 | 0.0361*** | 0.0424*** |
| | (0.0142) | (0.0150) | (0.0755) | (0.3968) | (0.2817) | (0.0078) | (0.0092) |
| **Intercepts and fixed effects** | | | | | | | |
| East German banks | -0.3510*** | 0.0097*** | -0.0488*** | -0.164 | -0.1823*** | 0.4145*** | 0.0070*** |
| | (0.0108) | (0.0003) | (0.0015) | (0.3508) | (0.0058) | (0.0357) | (0.0006) |
| Large banks | 2.3492*** | -0.0065*** | 0.0327*** | 0.1098 | 0.1221*** | | |
| | (0.0319) | (0.0001) | (0.0004) | (0.2348) | (0.0020) | | |
| Commercial banks | 0.3578*** | -0.0075*** | 0.0376*** | 0.1264 | 0.1405*** | | |
| | (0.0125) | (0.0003) | (0.0013) | (0.2705) | (0.0050) | | |
| Savings banks | -0.1628*** | 0.0118*** | -0.0593*** | -0.199 | -0.2212*** | | |
| | (0.0086) | (0.0006) | (0.0031) | (0.4259) | (0.0117) | | |
| Euro Area | -0.4961*** | 0.0338*** | -0.1703*** | -0.5718 | -0.6359*** | -0.2245*** | -0.1774*** |
| | (0.0095) | (0.0007) | (0.0033) | (1.2261) | (0.0127) | (0.0565) | (0.0447) |
| Offshore destination | -0.1526*** | 0.0026*** | -0.0131*** | -0.044 | -0.0489*** | -0.7185*** | -0.0023*** |
| | (0.0192) | (0.0003) | (0.0017) | (0.0945) | (0.0062) | (0.0912) | (0.0003) |
| Developing destination | -0.3885*** | 0.0729*** | -0.3668*** | -1.2316 | -1.3695*** | -1.0713*** | -0.1998*** |
| | (0.0194) | (0.0037) | (0.0184) | (2.6047) | (0.0689) | (0.0943) | (0.0176) |
| Financial center destination | 0.3274*** | -0.0056*** | 0.0281*** | 0.0943 | 0.1049*** | 1.1554*** | 0.0445*** |
| | (0.0159) | (0.0003) | (0.0014) | (0.2022) | (0.0052) | (0.0414) | (0.0016) |
| Constant | | | | | | 10.5808*** | |
| | | | | | | (0.5585) | |
| Cut-off 1 | 8.6399*** | | | | | | |
| | (0.1176) | | | | | | |
| Cut-off 2 | 12.5524*** | | | | | | |
| | (0.1206) | | | | | | |
| Cut-off 3 | 13.1031*** | | | | | | |
| | (0.1229) | | | | | | |

Notes: The selection equation (Extensive Margin) is estimated as an ordered probit model and includes unreported dummies for banking groups as exclusion restrictions. The dependent variable is the mode of foreign activities. The primary equation (Intensive Margin) is estimated with OLS. The dependent variable is the log volume of international assets. Time-fixed effects are included but not reported. Productivity is obtained using the method proposed by Levinsohn and Petrin 2003. For further variable descriptions, see the Data Appendix. ***Significant at 1% level. **Significant at 5% level. * Significant at 10% level.

Table A.8: Results per Banking Group

| | Extensive Margin | | | | | Intensive Margin | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All | Large | Com'cl | Savings | Coop's | All | Large | Com'cl | Savings | Coop's |
| **Productivity and selection** | | | | | | | | | | |
| Correction term | | | | | | 0.567*** | 1.178*** | 2.478*** | 3.634*** | 6.071*** |
| | | | | | | (0.037) | (0.072) | (0.098) | (0.107) | (0.103) |
| Productivity | 0.000*** | 0.004*** | -0.001*** | 0.031*** | 0.027*** | 0.015*** | 0.011*** | -0.006*** | 0.101*** | 0.112*** |
| | (0.000) | (0.001) | (0.000) | (0.001) | (0.001) | (0.000) | (0.001) | (0.000) | (0.003) | (0.003) |
| Size | 0.436*** | 0.390*** | 0.515*** | 0.253*** | 0.296*** | 0.526*** | 0.626*** | 1.483*** | 0.710*** | 1.309*** |
| | (0.003) | (0.032) | (0.009) | (0.006) | (0.004) | (0.012) | (0.044) | (0.040) | (0.020) | (0.020) |
| **Bank-specific variables** | | | | | | | | | | |
| Cost-income ratio | 0.007*** | 0.050*** | 0.008*** | -0.007*** | 0.009*** | -0.056*** | 0.014** | -0.034*** | -0.050*** | 0.021*** |
| | (0.000) | (0.004) | (0.001) | (0.002) | (0.001) | (0.001) | (0.006) | (0.002) | (0.005) | (0.002) |
| Return on equity | 0.002*** | -0,001 | 0.002*** | 0.002** | 0.005*** | 0.002** | -0.014*** | 0 | 0,003 | 0.022*** |
| | (0.000) | (0.003) | (0.000) | (0.001) | (0.000) | (0.001) | (0.005) | (0.001) | (0.002) | (0.001) |
| Capitalization | -0.019*** | 0.103*** | -0.010*** | -0.034*** | -0.023*** | 0.021*** | -0.128** | 0,002 | -0.183*** | -0.060*** |
| | (0.001) | (0.037) | (0.001) | (0.007) | (0.003) | (0.004) | (0.058) | (0.005) | (0.020) | (0.010) |
| Hidden reserves | -0.009*** | -0,243 | 0,005 | -0.010* | 0.020*** | -0.235*** | -0,173 | 0.316*** | 0.116*** | 0,017 |
| | (0.003) | (0.172) | (0.016) | (0.005) | (0.005) | (0.010) | (0.253) | (0.049) | (0.015) | (0.015) |
| Non-performing loans | 0,004 | 0,103 | -0.013*** | 0.055*** | 0.074*** | -0.081*** | 0,086 | -0.137*** | -0,04 | 0.324*** |
| | (0.003) | (0.095) | (0.004) | (0.019) | (0.008) | (0.012) | (0.145) | (0.015) | (0.053) | (0.024) |
| Loan-loss provisions | 0 | 0.047** | 0.001*** | -0.012*** | -0.011*** | 0.013*** | -0.055* | 0.014*** | 0,008 | -0.073*** |
| | (0.000) | (0.019) | (0.000) | (0.003) | (0.001) | (0.001) | (0.028) | (0.001) | (0.009) | (0.004) |
| **Country-specific variables** | | | | | | | | | | |
| GDP | 0.198*** | -0.131*** | 0.153*** | 0.328*** | 0.139*** | -1.010*** | -0.308*** | 0,012 | 0,022 | -1.019*** |
| | (0.005) | (0.048) | (0.018) | (0.011) | (0.007) | (0.021) | (0.073) | (0.062) | (0.039) | (0.027) |
| GDP per capita | 0.134*** | 0.125* | 0.135*** | 0.295*** | 0.045*** | 0.659*** | 1.477*** | 0.544*** | 2.067*** | 1.162*** |
| | (0.009) | (0.075) | (0.028) | (0.017) | (0.013) | (0.044) | (0.115) | (0.113) | (0.074) | (0.061) |
| German FDI | 0.288*** | 0.402*** | 0.175*** | 0.234*** | 0.357*** | 0.918*** | 0.782*** | 0.749*** | 1.063*** | 2.475*** |
| | (0.004) | (0.034) | (0.013) | (0.008) | (0.006) | (0.017) | (0.051) | (0.045) | (0.028) | (0.030) |
| Growth correlations | 0.128*** | 0,008 | -0.153*** | -0.080*** | 0.313*** | -0,025 | -0,064 | -0.273** | -0.641*** | 1.527*** |
| | (0.010) | (0.086) | (0.031) | (0.018) | (0.014) | (0.039) | (0.127) | (0.110) | (0.060) | (0.056) |
| Growth volatility | -0.074*** | -0,002 | -0.030*** | -0.041*** | -0.100*** | 0.130*** | 0,009 | 0.067** | 0.051*** | -0.180*** |
| | (0.003) | (0.021) | (0.008) | (0.005) | (0.004) | (0.012) | (0.032) | (0.031) | (0.019) | (0.019) |
| Distance | -0.343*** | -0,056 | -0.300*** | -0.457*** | -0.298*** | 0.388*** | -0.355*** | -0.695*** | -0.573*** | -0.379*** |
| | (0.004) | (0.041) | (0.014) | (0.008) | (0.006) | (0.017) | (0.059) | (0.051) | (0.036) | (0.027) |
| Concentration | 0.157*** | 0,199 | 0,109 | 0.380*** | 0.100*** | -3.917*** | -2.122*** | -2.573*** | -2.725*** | -3.663*** |
| | (0.021) | (0.180) | (0.068) | (0.041) | (0.028) | (0.083) | (0.276) | (0.234) | (0.137) | (0.107) |
| Activity restrictions | -0.088*** | 0.046*** | -0.040*** | -0.112*** | -0.088*** | 0.024*** | 0.076*** | -0.078*** | -0.163*** | -0.317*** |
| | (0.002) | (0.017) | (0.006) | (0.004) | (0.002) | (0.007) | (0.026) | (0.020) | (0.013) | (0.010) |
| Capital restrictions | -0.111*** | 0,004 | -0,011 | -0.113*** | -0.129*** | 0.036*** | 0.067** | 0,033 | -0.267*** | -0.368*** |
| | (0.002) | (0.019) | (0.007) | (0.004) | (0.003) | (0.008) | (0.029) | (0.023) | (0.013) | (0.012) |
| Institutional quality | 0,01 | 0.218* | 0,066 | -0.236*** | 0.128*** | -0.224*** | -0.906*** | -0.758*** | -0.790*** | 0.544*** |
| | (0.014) | (0.114) | (0.043) | (0.026) | (0.019) | (0.057) | (0.174) | (0.156) | (0.092) | (0.072) |
| **Intercepts and fixed effects** | | | | | | | | | | |
| East German banks | -0.351*** | -0.395*** | -0.163*** | -0,005 | -0.245*** | 0.414*** | -1.701*** | 0.601*** | 0.871*** | -0.226*** |
| | (0.011) | (0.098) | (0.050) | (0.024) | (0.017) | (0.036) | (0.147) | (0.169) | (0.067) | (0.052) |
| Euro Area | -0.496*** | -0.188* | -0,027 | -0.420*** | -0.621*** | 2.231*** | 0.624*** | 0.640*** | 1.574*** | 0.345*** |
| | (0.009) | (0.098) | (0.032) | (0.019) | (0.012) | (0.036) | (0.136) | (0.105) | (0.059) | (0.058) |
| Offshore destination | -0.153*** | 0.576*** | 0.149*** | 0.072** | -0.412*** | -0.718*** | 0.883*** | -0,025 | 0.253* | -3.298*** |
| | (0.019) | (0.143) | (0.055) | (0.034) | (0.029) | (0.091) | (0.219) | (0.216) | (0.141) | (0.140) |
| Developing country | -0.389*** | 0,137 | -0.222*** | -0.734*** | -0.254*** | -1.071*** | -0,254 | -0,194 | -4.291*** | -2.575*** |
| | (0.019) | (0.155) | (0.059) | (0.036) | (0.027) | (0.094) | (0.235) | (0.243) | (0.159) | (0.131) |
| Financial center | 0.327*** | 0.703*** | 0.257*** | 0.234*** | 0.379*** | 1.155*** | 1.505*** | 1.428*** | 1.747*** | 0.577*** |
| | (0.016) | (0.149) | (0.053) | (0.036) | (0.020) | (0.041) | (0.221) | (0.145) | (0.070) | (0.049) |
| Constant | | | | | | 10.581*** | -3.113** | -7.036*** | -23.471*** | -23.504*** |
| | | | | | | (0.559) | (1.549) | (1.485) | (1.120) | (0.988) |
| Cut-off 1 | 8.640*** | 5.351*** | 7.288*** | 9.619*** | 8.223*** | | | | | |
| | (0.118) | (1.032) | (0.377) | (0.231) | (0.157) | | | | | |
| Cut-off 2 | 12.552*** | 9.313*** | 10.337*** | 14.642*** | 12.945*** | | | | | |
| | (0.121) | (1.047) | (0.381) | (0.253) | (0.174) | | | | | |
| Cut-off 3 | 13.103*** | 10.247*** | 10.867*** | 14.812*** | | | | | | |
| | (0.123) | (1.048) | (0.383) | (0.262) | | | | | | |
| Observations | 343,770 | 3,185 | 24,080 | 83,300 | 233,205 | 94,329 | 2,839 | 9,131 | 28,874 | 53,471 |
| $R^2$ | 0.412 | 0.375 | 0.326 | 0.407 | 0.43 | 0.29 | 0.656 | 0.315 | 0.251 | 0.356 |

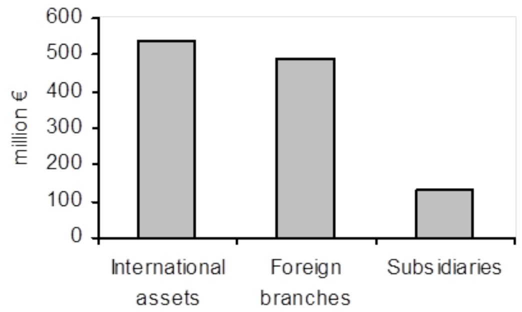
Notes: Large banks represent the largest commercial banks, Landesbanken, and central cooperatives. Commercial banks are privately owned banks; savings and cooperative banks are regionally operating small banks, owned either mutually or by (regional) governments. The selection equation (Extensive Margin) is estimated as an ordered probit model and includes unreported dummies for banking groups as exclusion restrictions. The dependent variable is the mode of foreign market entry. The primary equation (Intensive Margin) is estimated with OLS. The dependent variable is the log volume of international assets. Time-fixed effects are included but not reported. The sample spans the period 2002 to 2006. Productivity is obtained with the method proposed by Levinsohn and Petrin 2003. For further variable descriptions, see the Data Appendix. ***Significant at 1% level. **Significant at 5% level. * Significant at 10% level.

Table A.9: Results Using Alternative Productivity Measures

| | Levinsohn-Petrin productivity measure | | Cost efficiency | | Labor productivity | |
|---|---|---|---|---|---|---|
| | Extensive margin | Intensive margin | Extensive margin | Intensive margin | Extensive margin | Intensive margin |
| **Productivity and selection** | | | | | | |
| Correction term | | 0.4414*** | | -0.1062** | | 0.3302*** |
| | | (0.0378) | | (0.0430) | | (0.0421) |
| Productivity | 0.0002** | 0.0207*** | 0.3034*** | 0.7807*** | 0.0225 | -7.2568*** |
| | (0.0001) | (0.0003) | (0.0371) | (0.1167) | (0.0359) | (0.1273) |
| Size | 0.4216*** | 0.6491*** | 0.4110*** | 0.6352*** | 0.4279*** | 0.5484*** |
| | (0.0029) | (0.0113) | (0.0035) | (0.0132) | (0.0033) | (0.0129) |
| **Bank-specific variables** | | | | | | |
| Return on equity | 0.0016*** | -0.0012 | 0.0001 | -0.0111*** | 0.0019*** | -0.0016* |
| | (0.0002) | (0.0008) | (0.0004) | (0.0013) | (0.0002) | (0.0008) |
| Capitalization | -0.0143*** | -0.0197*** | -0.0189*** | -0.0606*** | -0.0132*** | 0.0394*** |
| | (0.0012) | (0.0037) | (0.0019) | (0.0058) | (0.0013) | (0.0042) |
| Hidden reserves | -0.0051 | -0.2489*** | -0.0050 | -0.3629*** | -0.0012 | -0.3346*** |
| | (0.0032) | (0.0098) | (0.0039) | (0.0118) | (0.0036) | (0.0107) |
| Non-performing loans | 0.0081** | -0.1587*** | 0.0276*** | -0.3147*** | 0.0140*** | -0.0639*** |
| | (0.0033) | (0.0125) | (0.0063) | (0.0207) | (0.0035) | (0.0138) |
| Loan-loss provisions | -0.0002 | 0.0146*** | -0.0030*** | 0.0145*** | -0.0004 | 0.0057*** |
| | (0.0003) | (0.0011) | (0.0009) | (0.0025) | (0.0004) | (0.0012) |
| **Country-specific variables** | | | | | | |
| GDP | 0.1978*** | -1.0262*** | 0.1992*** | -1.2180*** | 0.1968*** | -1.1101*** |
| | (0.0054) | (0.0215) | (0.0066) | (0.0254) | (0.0063) | (0.0239) |
| GDP per capita | 0.1344*** | 0.6599*** | 0.2041*** | 0.6751*** | 0.1920*** | 0.7154*** |
| | (0.0094) | (0.0443) | (0.0113) | (0.0543) | (0.0107) | (0.0506) |
| German FDI | 0.2875*** | 0.8964*** | 0.2870*** | 0.8508*** | 0.2792*** | 0.8988*** |
| | (0.0042) | (0.0167) | (0.0050) | (0.0196) | (0.0047) | (0.0185) |
| Growth correlations | 0.1278*** | -0.0450 | 0.1100*** | 0.2768*** | 0.1000*** | 0.2913*** |
| | (0.0099) | (0.0392) | (0.0115) | (0.0458) | (0.0109) | (0.0432) |
| Growth volatility | -0.0739*** | 0.1423*** | -0.0664*** | 0.2220*** | -0.0626*** | 0.1955*** |
| | (0.0026) | (0.0123) | (0.0033) | (0.0151) | (0.0031) | (0.0141) |
| Distance | -0.3420*** | 0.4205*** | -0.3457*** | 0.6853*** | -0.3408*** | 0.5406*** |
| | (0.0043) | (0.0174) | (0.0051) | (0.0206) | (0.0048) | (0.0196) |
| Concentration | 0.1566*** | -3.9640*** | 0.0452* | -4.5045*** | 0.0545** | -4.3979*** |
| | (0.0211) | (0.0834) | (0.0247) | (0.0969) | (0.0234) | (0.0911) |
| Activity restrictions | -0.0875*** | 0.0333*** | -0.0960*** | 0.0610*** | -0.0914*** | 0.0266*** |
| | (0.0019) | (0.0071) | (0.0023) | (0.0084) | (0.0022) | (0.0080) |
| Capital restrictions | -0.1106*** | 0.0464*** | -0.0990*** | 0.1233*** | -0.0944*** | 0.0947*** |
| | (0.0021) | (0.0079) | (0.0025) | (0.0093) | (0.0023) | (0.0088) |
| Institutional quality | 0.0102 | -0.2446*** | -0.0818*** | -0.4462*** | -0.0671*** | -0.5125*** |
| | (0.0142) | (0.0571) | (0.0167) | (0.0676) | (0.0158) | (0.0636) |
| **Intercepts and fixed effects** | | | | | | |
| East German banks | -0.3106*** | 0.2396*** | -0.2783*** | 0.3859*** | -0.3078*** | 0.5648*** |
| | (0.0106) | (0.0358) | (0.0133) | (0.0442) | (0.0121) | (0.0407) |
| Euro Area | -0.4949*** | 2.2960*** | -0.5000*** | 2.3275*** | -0.4737*** | 2.1158*** |
| | (0.0095) | (0.0363) | (0.0113) | (0.0436) | (0.0107) | (0.0410) |
| Offshore destination | -0.1537*** | -0.6344*** | -0.0593*** | -0.6569*** | -0.0683*** | -0.7440*** |
| | (0.0192) | (0.0922) | (0.0226) | (0.1101) | (0.0215) | (0.1031) |
| Developing country | -0.3887*** | -1.0710*** | -0.4442*** | -0.7433*** | -0.4212*** | -0.8182*** |
| | (0.0194) | (0.0953) | (0.0232) | (0.1164) | (0.0220) | (0.1088) |
| Financial center | 0.3262*** | 1.1933*** | 0.4053*** | 1.2738*** | 0.3587*** | 1.2286*** |
| | (0.0158) | (0.0419) | (0.0196) | (0.0503) | (0.0180) | (0.0475) |
| Cut-off 1 | 8.4372*** | | 8.8488*** | | 8.6003*** | |
| | (0.1181) | | (0.1454) | | (0.1353) | |
| Cut-off 2 | 12.3410*** | | 12.8481*** | | 12.5114*** | |
| | (0.1209) | | (0.1488) | | (0.1384) | |
| Cut-off 3 | 12.8838*** | | 13.4032*** | | 13.0645*** | |
| | (0.1231) | | (0.1512) | | (0.1409) | |
| Constant | | 8.4291*** | | 13.0875*** | | 11.8497*** |
| | | (0.5622) | | (0.6721) | | (0.6174) |
| Observations | 343,770 | 94,329 | 239,820 | 68,702 | 268,975 | 74,954 |
| $R^2$ | | 0.2741 | | 0.2494 | | 0.2709 |

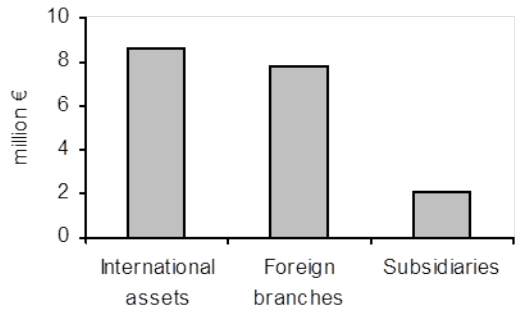
Notes: Levinsohn-Petrin is the same productivity used in the remaining Tables. Cost efficiency is an estimate of systematic deviations from optimal (latent) cost frontiers as in Levinsohn and Petrin 2003. Labor productivity is total assets scaled by total employment. For details, see Section 2.2.3 of the main text. The selection equation (Extensive Margin) is estimated as an ordered probit model and includes unreported dummies for banking groups as exclusion restrictions. The dependent variable is the mode of foreign market entry. The primary equation (Intensive Margin) is estimated with OLS. The dependent variable is the log volume of international assets. Time-fixed effects are included but not reported. The sample spans the period 2002 to 2006. Productivity is obtained with the method proposed by Levinsohn and Petrin 2003. For further variable descriptions, see the Data Appendix. ***Significant at 1% level. **Significant at 5% level. * Significant at 10% level.

Figure A.1: Volumes of Investment: Total Volume




Notes: Total volume is in EUR millions and indicates the total international assets of all banks in a specific Mode, aggregated across countries. Mode 1 (International assets), Mode 2a (Foreign branches), and Mode 2b (Branches and subsidiaries).

Figure A.2: Volumes of Investment: Mean Volume




Notes: Mean volume is in EUR millions and gives the mean international assets of banks. Mode 1 (International assets), Mode 2a (Foreign branches), and Mode 2b (Branches and subsidiaries), aggregated across countries.

# 3

# Do banks benefit from internationalization? Revisiting the market power-risk nexus[1]

The ongoing turmoil in the international financial system calls the potential benefits of bank globalization into question (see Global Committee on the Global Financial System, 2011). Concerns include that large, internationally active banks may enjoy too much market power and that bank internationalization may increase bank risk. Many studies analyze the effects of foreign banks in destination economies[2] or performance differences between domestic and foreign banks abroad[3]. But evidence regarding the influence of bank internationalization on market power and risk in the home country is virtually absent from the literature. We close this gap and analyze the implications of bank internationalization on the domestic market power-risk nexus. We use detailed bank-level

[1]This chapter draws on joint work with Claudia M. Buch and Michael Koetter. It relies on an updated version of Buch et al. (2010) and is forthcoming in the *Review of Finance* (2012, Copyright by Oxford University Press). Section 3.5 details on my contribution to these papers.

[2]For example, Mian (2006) and Detragiache et al. (2008) show that credit supply declines after the entry of foreign banks in host countries. Giannetti and Laeven (2012) report on the basis of within-host country differences among credit relationships that access to credit is not different between domestic and foreign banks. Survey-based evidence by Popov and Udell (2012), in turn, indicates that international banks hit by the crisis contracted loan supply. These studies do not elaborate on the effects of foreign activities on banks in the home country.

[3]See Claessens and van Horen (2012) for recent evidence and an overview of the literature.

data on financial accounts and international exposures of all German banks provided by the *Deutsche Bundesbank* (see Buch et al., 2011a). The data allow us to identify the number of countries where banks are active (the *extensive* margin), the share of foreign relative to total assets (the *intensive* margin), and the different modes of entry into foreign markets (cross-border asset holdings versus foreign branches). A key contribution of this paper is the ability to differentiate between cross-border activities and operating branches abroad.[4] Based on prudential financial accounts data, we estimate mark-ups as the (scaled) difference between average revenues and marginal cost, the Lerner index. It is a bank-specific measure of market power (see Koetter et al. (2010)). To find a measure of bank risk, we use distress events as collected by the *Deutsche Bundesbank* (see Dam and Koetter (2012)). We apply a system estimator that accounts for the simultaneous determination of market power and risk conditional on bank internationalization.

This paper contributes to three strands of previous literature. First, several papers focus on the determinants of cross-border expansion by banks (see Berger et al. (2003); Buch and Lipponer (2007); De Haas and Van Horen (2011); Focarelli and Pozzolo (2005)). These studies find that regulatory and cultural barriers limit the international expansion of banks, which are overcome more easily by larger and more profitable banks. We account for this bank heterogeneity but ask the reverse question: Given that banks are active abroad, how does this foreign presence influence their market power-risk tradeoff? Especially banks with sufficient margins and/or more appetite for risk might decide to expand internationally. To address potential endogeneity concerns, we adapt the method of Frankel and Romer (1999). These concerns arise from possibly existing correlations among foreign activities, mark-ups, and risk among all banks in a large, developed banking system.[5]

Second, whereas a plethora of studies analyze the determinants of bank risk, these studies usually ignore the role of bank internationalization.[6] Amihud et al. (2002) examine the risk effects of cross-border bank mergers and report that, on average, cross-border

[4]Usually, banks with a majority stake in a host country bank are considered international, see e.g. Detragiache et al. (2008). But cross-border lending and foreign presences are at least as important a channel for international banking.

[5]They use the geographic component of international trade as an instrument for actual trade. We adapt their method to a panel context and exploit the fact that foreign GDP is a time-varying variable, which is exogenous to the individual bank.

[6]See, for example, De Nicolo (2000), Gonzalez (2005), and Beltratti and Stulz (2011).

bank mergers do not change the risk of acquiring banks. Meon and Weill (2005) study the impact of cross-border mergers in Europe on banks' exposures to macroeconomic risks. They find potential gains in risk diversification from cross-border mergers. Ongena et al. (2011) show that loose home-country regulation and supervision are associated with more risk taking by internationally active banks. We extend these studies because we analyze *all* modes of entry into foreign markets, not just mergers and acquisitions. Besides, we adjust foreign exposures for GDP growth and stock market return correlation between destination countries and the home market, Germany.

Third, the market power-risk nexus for banks has also been extensively studied. Many cross-country studies report a negative relationship between market power and bank risk (see, e.g. Beck, 2008; Schaeck et al., 2009). This result is in line with the theories of Allen and Gale (2004) and Martinez-Miera and Repullo (2010) who argue that less intense competition increases banks' margins and buffers against loan losses. Alternatively, Boyd and De Nicolò (2005) show that banks with more market power may inflict excessively high funding costs on corporate customers, ultimately transcending into worsening default rates, and subsequently bank instability. For a sample of 60 developing countries, Ariss (2010) confirms a negative relationship between market power and bank stability. Aside from the general neglect of international bank activities, the failure of virtually all empirical studies to account for the simultaneous relationship between banks' mark-ups and risk may partly explain the controversial empirical evidence. Similar to Degryse and Ongena (2001) we therefore take this simultaneity between (continuous) Lerner mark-ups and (discrete) distress events explicitly into account and specify a system of two equations.

The main results of this paper are threefold.

First, after accounting for the joint determination of market power and risk and after including banks' international activities, we find a negative relationship between market power and risk. This finding aligns with the majority of the empirical market power-risk nexus literature. Second, we find that larger international exposures in terms of volume (*intensive* margin) imply higher market power at home as suggested by Lerner indices. Our key contribution to distinguish between different foreign market entry modes now takes center stage: The operations of foreign branches rather than mere cross-border transactions drive the positive effect of higher foreign volumes on domestic market power.

This result could indicate that the gains from a larger customer pool on core markets enhance the ability of banks to generate private information that can also be beneficial in home markets to generate mark-ups (see Hauswald and Marquez, 2006). We further find that activities in more foreign markets (*extensive* margin) reduce domestic market power which is also driven by the activities of branches. Apparently, only some banks can reap the profits from internationalization, whereas the costs of monitoring a large portfolio outweigh diversification benefits for others.

Third, empirical evidence about how internationalization shapes risk is rather weak. We do only find significant effects when considering the foreign business of branches. In this light, maintaining a network of branches in many countries (*extensive* margin) lowers the risk of the domestic parent bank. However, a higher volume of foreign operations through branches (*intensive* margin) goes along with more risks for the domestic parent bank.

In Section 3.1 we develop theoretical hypotheses regarding the relationship between bank internationalization and the market power-risk nexus. In Section 3.3 we present the data and descriptive statistics. The empirical model is described in Section 3.3, followed by regression results in Section 3.4 and conclusions in Section 3.5.

## 3.1 Theoretical Hypothesis

The core research question is whether international activities affect the market power and risk of banks. We develop hypotheses based on the banking literature that deals with the determinants of global banking, portfolio effects, and the market power-risk nexus.

From a theoretical point of view, the relationship between market power and bank risk is ambiguous. It might be negative for two reasons (see Allen and Gale, 2004). First, because more concentrated banking systems reduce incentives of bankers to lend recklessly. Second, because supervision by regulators might be more effective in more concentrated systems. Hauswald and Marquez (2006) further show that increasing competitive pressure, for instance due to foreign contestants, may reduce the customer pool of the average bank, and thus a domestic bank's ability to generate private information. Larger information asymmetries can then increase average credit risk. Alternatively, market power may increase risk taking if banks can roll over loan risk by charging higher interest rates to customers (see Boyd and De Nicolò, 2005). If borrowers endogenously choose the risk of their project, an increase in lending rates increases risk due to an adverse selection effect. Martinez-Miera and Repullo (2010) show that this *risk shifting effect* is due to the assumption that loan default rates are perfectly correlated. They introduce imperfect correlation of loan default rates and show that there is an additional margin effect: More competition lowers (expected) loan rates and thus reduces buffers against loan losses. Banks become riskier. The net effect is ambiguous, and we will thus explore which effect dominates in the German data.

***H1: The relationship between bank market power and risk is ambiguous.***

We measure market power with bank-specific Lerner indices, which equal the difference between average revenues and marginal costs, scaled by average revenues.[7] Internationalization may affect bank market power through costs, revenues, or both. In contrast to literature on multinational corporations, a generally accepted model of the international bank does not exists (see Goldberg, 2004). However, existing literature implicitly indicates how internationalization should affect the two components of Lerner indices, average revenues and marginal cost.

Regarding the revenue channel, internationalization should increase mark-ups because banks have more opportunities to generate private information that can also be exploited in the domestic market. Ball and Tschoegl (1982) and Brealey and Kaplanis (1996) have been among the first to show that banks follow their corporate customers abroad. Private information about foreign markets that is acquired through these relationships is valuable because it may facilitate the venturing abroad of the very bank's other domestic customers. Such information can therefore provide banks with a competitive advantage due to international activities.[8] This aspect could be particularly relevant in Germany, where many mid-sized firms are internationally active and the banking market is characterized

[7]We prefer Lerner mark-ups over, for example, bank return measures because we are primarily interested in analyzing the effect of bank internationalization on the market power-risk nexus. Furthermore, accounting-based return measures neglect random noise (see Bauer et al., 1998) and too few German banks are listed to permit the use of market-based return measures to assess competition in the entire banking industry. Given the ongoing debate in the literature on how to measure competition and market power in banking (Delis and Kouretas, 2011), we consider below also simple market shares as well as Boone (2008) indicators as alternatives to the Lerner index.

[8]See Degryse and Ongena, 2005 for a discussion of the role of distance in banking

by many small and regionally focused banks. Indeed, anecdotal evidence suggests that the German "Sparkassen" perceive their limited presence on foreign markets to be a disadvantage compared to larger commercial banks. Likewise, Brickley et al. (2011) show that small community banks in the U.S. prefer so-called banker's banks over large, national financial institutions to act as correspondent banks to avoid sharing private information on local business with these larger potential competitors.[9] Banker's banks are thus a specific form of direct investment by community banks to conduct out-of-state business in order to preserve an informational, i.e. competitive advantage inherent to their local business relationships. Overall, we expect that foreign activities are positively related with higher average revenues due to superior abilities to generate private information as well as a broader scope of potential customers.

The second channel through which foreign bank activities can affect market power relies on marginal costs. In the banking literature, Hauswald and Marquez (2006) emphasize that new contestants reduce the average number of customers per bank. This decline erodes the ability to properly assess credit applicants because the pool of private information sources contracts. Reduced information generation capability can be countered by a more intensive use of information and communication technology, which increases the screening cost of the bank. International activities provide the bank with access to additional information sources, for instance by means of a larger customer base, but also by means of the mere addition of country expertise. Ceteris paribus, such banks should have lower cost to generate private information and thus exhibit larger mark-ups. With reference to the international trade literature, differences in marginal costs across firms reflect productivity differences which in turn are often assumed to be exogenous. However, Lileeva and Trefler (2010) show that small Canadian export starters invest in technology to raise their productivity sufficiently enough as to compete in foreign markets. International trade, yet, generates learning effects, which in turn leads to endogenous technology improvements that reduce marginal cost. In this vein, international banks might improve their productivity, reduce their marginal costs, and thus improve their mark-ups. Overall, we expect both the information generation effect and the productivity effect of international activities to reduce the marginal costs. The market power of banks should therefore

[9] Banker's banks are cooperatives that are owned by community banks. They provide correspondent banking services, such as loan participation, check clearing, but also international services.

improve due to higher revenues and reduced marginal costs.

***H2: The expected impact of internationalization on market power at home is positive.***

Modeling banks as portfolio managers that optimize their expected utility as a positive function of expected profits and a negative function of expected portfolio risk, has a relatively long tradition in the banking literature (see Rochet, 2008). Given the close relationship between returns and mark-ups to measure market power, this literature provides guidance regarding the effects of international activities on risk. The international diversification of exposures may reduce bank risk (see, e.g., Berger 2000) if the correlation between domestic and foreign exposure returns is sufficiently low or even negative. Therefore, we control for both correlations: first for the correlation between destination country output and equity returns and second for correlation between German output and equity returns.[10]

Two effects might counterbalance this potential diversification effect. First, banks have incentives to shift risk to countries where the regulatory safety net and its associated implicit and explicit guarantees are underpriced (see John et al., 1991, 2000). Second, an internationally active bank may face severe monitoring problems related to the loan customer base or the operating cost structure of managing numerous large international exposures. Taken together, the joint effect might ultimately increase the risk of the bank (Winton, 1999). If monitoring and information costs are high, bank risk might increase, in particular when banks operate on geographically distant markets.

To capture diversification effects, we use information on the number of countries in which banks are active (the *extensive* margin). The expected impact on risk is negative. The effect of the share of foreign activities in total assets (the *intensive* margin) on bank risk is ambiguous. We do also explore the extent to which it depends on the correlation of destination markets with the German market and geographical distance, with both presumably increasing risk.

***H3: A greater degree of diversification of foreign assets lowers bank risk. The impact of a higher volume of foreign assets is ambiguous.***

[10] We consider output and equity correlations for lack of preferable data on the returns on foreign financial exposures.

## 3.2 Data and Descriptive Statistics

To test these three hypotheses on the relationship between bank internationalization, market power, and risk, we use several proprietary bank-level datasets provided by the *Deutsche Bundesbank*. The detailed database on banks' international assets is an important novelty of this paper[11]. This so-called "External Position Report" provides comprehensive information on international balance-sheet assets of German banks and their foreign branches month-by-month[12], and country-by-country. Foreign assets comprise loans to banks and non-banks, stocks, and bonds but exclude off-balance sheet items except irrevocable credit commitments. The sample period ranges from 2003 to 2006. Reporting thresholds on international positions were abolished in 2002. We focus on the pre-crisis period to exclude the effect of government interventions on international bank activities. Instead, we focus on bank behavior for a period which is not affected by such interventions.

We complement the "External Position Report" with information from prudential financial accounts. Each bank with a German banking license has to submit these data to the supervisory authority. These datasets refer to unconsolidated, individual banks. Financial statements include the assets of foreign branches, but not subsidiaries. To measure internationalization, market power, and risk at the same level, we therefore have to disregard international exposures held through subsidiaries because we lack the necessary data to estimate market power and risk for the latter. This approach ensures that we assess the domestic market power-risk nexus conditional on the international exposures held by each German bank that constitutes a legal entity. These legal entities are also the subject of domestic prudential supervision, antitrust regulation, deposit insurance, and the like.[13] Details on the definitions and sources of variables are in Appendix B.2.

[11]For previous research using these data, see Buch et al. (2011a,b) or Duewel et al. (2011).

[12]In this paper, we draw on annual data.

[13]Note that subsidiaries are subject to host country control, e.g. regarding capital requirements. Clearly, the recent experience of various German banks, especially internationally active Landesbanken such as Sachsen LB, vividly illustrates that excessive risk raking abroad through subsidiaries can ultimately lead to the failure of the entire bank holding company. We therefore consider foreign activities through subsidiaries as a robustness test. Results for this pre-crisis sample mimic the findings reported below for foreign branches. But clearly, further research dissecting more explicitly the implications of internal capital markets, e.g. along the lines of De Haas and Van Lelyveld (2010), is warranted. Given the data limitations regarding subsidiaries, but also unknown bank holding company structures, such an approach is outside the scope of this paper

### 3.2.1 Measuring Bank Internationalization

We obtain data on cross-border assets held by individual banks and foreign assets held by their respective foreign branches from the "External Position Report". The vast majority of banks reports international assets in at least one foreign country. On average, only 28 out of a total of 2,235 banks that were active in Germany during the sample period are purely domestic.[14] Maintaining a network of foreign branches reveals as cost-intensive. Only 27 banks choose branches as foreign market entry mode.[15] These banks might be considered as the truly global banks.

We compute two measures of internationalization at the bank level. First, we compute the *extensive* margin as the number of countries where a bank holds cross-border assets or operates a foreign branch. If a bank runs several branches in a specific host country, we include this as one observation per bank and country. The difference in the *extensive* margin between banks with and without foreign branches is substantial. The average bank holds foreign assets in approximately 14 countries but hardly any foreign branches (0.087, Column 1, Table B.1). Banks with foreign branches, in contrast, hold foreign assets in about 42 countries and operate foreign branches in approximately four countries on average. In this small group of truly international banks, the largest ones have exposures to all 71 countries sampled, and they operate branches in as many as 32 countries (Column 8, Table B.1).

The second measure of bank internationalization is the volume of foreign activities relative to total assets, the *intensive* margin. We aggregate all foreign assets of bank $i$ in destination country $j$. We also separate the cross-border assets of the domestic headquarters from those held through foreign branches. Note the difference between the destination and host country perspectives that applies to foreign branches. Regarding the *extensive* margin, we consider the number of host countries where banks operate foreign branches, say Turkey. In contrast, we aggregate the *intensive* margin, i.e. financial assets, across destination countries to which a foreign branch ultimately lends. The hypothetical Turkish branch may lend primarily to host country counterparties, but also to third-country borrowers, say Greece. Hence, the risk of these foreign exposures would be poorly reflected

[14] See Buch et al. (2011a) for details.
[15] 37 banks run subsidiaries and/or branches.

by the host country alone. Considering the host country for the *intensive* margin captures a bank's abilities to acquire host country expertise whereas the destination country perspective captures the actual geographical diversification of foreign exposures. Also, this handling accounts for the effect that branches in financial centers primarily serve as a lending platform to third-party destination countries. Column 1 of Table B.1 shows that, on average, German banks hold about 4.4% of their total assets abroad through one of these channels. The foreign asset share of banks with foreign branches in isolation is much higher, around 34.7%.

*Extensive* and *intensive* margins do neither account directly for the co-movement between destination countries and the German market nor do different distances to Germany. Both aspects potentially affect market power and risk though. Therefore, we first specify the average correlation between foreign equity markets and real output between the destination country and Germany as well as the geographical distance between both. If, for instance, a given bank is exposed to 10 foreign countries, we include the average of the correlations and distance between these markets and the German markets as an additional covariate. Formally, this measure is given by $\frac{1}{N_i}\Sigma_{j=1}^{N_i}\delta_j$ where $N_i$ is the number of (host) countries in which bank $i$ is active (the *extensive* margin), and $\delta_j$ is the correlation between market $j$ and the German market or the bilateral distance. Because we do not have the specific returns on each market for each bank, we proxy returns by stock market returns and GDP growth.

Second, we weight foreign exposures (the *intensive* margin) by correlations as well as geographic distance. We compute for each bank $\frac{1}{A_i}\Sigma_{j=1}^{N_i}FA_{ij}\delta_j$ and specify correlation- or distance-weighted *intensive* margins as a second covariate.

### 3.2.2 Measuring Market Power

Our preferred measure of bank market power is the Lerner index, i.e. the difference between average revenues and marginal cost, scaled by average revenues. Two clear advantages over other measures of market power are that the Lerner index nests different models of competition and that it yields a measure at the level of the individual bank (see Degryse et al. (2009)). A higher Lerner index indicates a lower degree of competition (a higher degree of market power). We compute the Lerner index from stochastic cost and profit frontier analysis to obtain competition measures net of operational slack (see Koetter et al. (2010)). Marginal costs are the total derivative of estimated operating cost frontiers with respect to four outputs (interbank loans, customer loans, securities, and off-balance sheet items). We estimate average revenues from a stochastic profit frontier. To account for the three-tier banking structure in Germany banks and the fact that banks operate under different technology regimes, we estimate both frontiers as latent classes shown by Koetter and Poghosyan (2009).[16] Average revenues and marginal costs comprise revenues and costs associated with domestic, cross-border, and foreign branch asset holdings. The Lerner index has the advantage that it can be computed for each individual bank and for each year, and that it provides a measure of market power which encompasses revenue and cost aspects. Bank competition measures are controversially discussed (see Carbo et al. (2009)). Boone (2008) suggests as an alternative to directly measure how (cost) inefficiency, as reflected by differences in marginal cost, affects bank profitability. We therefore estimate how profits ($\pi_i$) change in response to bank's marginal costs ($c_i$ ) (see also Degryse et al. (2009): 36-37): $ln\left(\pi_i\right) = \alpha - \beta ln\left(c_i\right)$. The coefficient $\beta$ is the so-called Boone-indicator of market power, it gives the profit elasticity. Larger $\beta$ hint at more intense competition and hence less market power. Therefore, $\beta$ is negative in light of a market power interpretation. As noted by Delis (2012) lower market power is reflected by larger magnitudes of the Boone indicator. We estimate Boone indicators for each bank using bank-specific data that are, in contrast to the international exposure data, available from 1994 until 2010.

Summary statistics for the bank-level variables are provided in Table B.2. Mean Lerner indices of 23 basis points are in line with results reported by De Guevara and Maudos (2007) for a sample of European banks and Koetter and Poghosyan (2009) for German banks. The mean Lerner index is smaller for banks with foreign branches (15 basis points), which may result from the greater degree of competitive pressure these banks are exposed to on international markets.

[16]See Koetter and Poghosyan (2009) for a more detailed discussion. The German banking system is characterized by a three-tier structure of savings, cooperative, and (private) commercial banks. These banks differ with regard to their ownership structures, their ability to expand regionally, and their core business model. A latent class model permits production parameters to vary and hence, different scale economies and marginal cost properties for different groups of banks such as large commercial and central savings banks versus small regional banks.

### 3.2.3 Measuring Bank Risk

To measure bank risk, previous literature often uses so-called *z-scores*, non-performing loans, or the volatility of bank-level reserves, profits, or non-performing loans (see e.g. Beck, 2008; Laeven and Levine, 2009). Most of these measures capture important aspects of bank risk, but not necessarily the risk that the entire financial institution is distressed and ceases to exist. The German regulator defines distress as "a situation in which an institutions existence will be endangered without support measures" (Bundesbank, 2007: 75). Support measures are either exits through restructuring mergers ordered by the *Federal Supervision Authorities* (*Bundesanstalt für Finanzdienstleistungsaufsicht – BaFin*) or capital injections by bank-pillar specific insurance schemes (Dam and Koetter, 2012). The Bundesbank records distress events, which thus reveal when the regulator deems the ultimate risk faced by a bank as too high, namely, to fail. Our preferred measure of risk is therefore bank distress. Table B.2 shows that the distress frequency is higher for banks that operate foreign branches (7%) as compared to the full sample (4%). Lerner indices and the likelihood of distress are estimated using covariates that are lagged by one year to avoid simultaneity by construction. We follow the bank failure literature to select the covariates shown in Table B.2 to explain the occurrence of bank distress (see, e.g., Wheelock and Wilson, 1995). Measuring bank risk as the official declaration of distress by the regulator is appealing. Yet, larger banks have not experienced distress during the sample the period. To obtain a measure of risk for all banks, we follow Laeven and Levine (2009) and compute for each bank a *z-score* as $z = \frac{E/A + RoA}{\sigma_{RoA}}$ where $E/A$ is the capital-asset-ratio, $RoA$ denotes return on assets, and $\sigma_{RoA}$ denotes the standard deviation of $RoA$, which is calculated using a rolling window of five years. Z-scores measure the extent to which bank equity is sufficient to cover losses. Higher z-scores indicate less risky banks.

## 3.3 Empirical Model

When choosing their business model, banks implicitly choose also their degree of market power as well as the risk structure of their activities. This is a simultaneous choice. We thus need to estimate the relationship between market power and risk jointly when analyzing the impact of internationalization on the market power-risk nexus. Contrary to previous banking studies that specify simultaneous risk and return equation models based on continuous variables (see e.g. Kwan and Eisenbeis (1997)), the distress indicator to measure risk in this study is binary. Therefore, we employ an instrumental-variables procedure suggested by Rivers and Vuong (1988) and described in Wooldridge (2002) for systems with an endogenous binary variable.[17]

The dependent variable in the market-power equation is the Lerner index $LI_{it} = LI^*_{it}$ , a fully observed continuous variable. Because the probability of distress is not observable, we proxy it by the binary indicator of an observable distress event, such that $PD_{it} = I\left(PD^*_{it} > 0\right)$ . As a first step, we estimate reduced-form Equations 3.1 and 3.2 to generate instruments for market power (Lerner index = LI) and risk (probability of distress = PD) :

$$LI_{it} = \Pi_1' X_{it-1} + v_{1,it} \tag{3.1}$$

$$PD_{it} = \Pi_2' X_{it-1} + v_{2,it} \tag{3.2}$$

where $i$ is a bank-index and $t$ denotes time. We lag the explanatory variables by one period to avoid simultaneity (see $X_{it-1}$). The market-power Equation 3.1 is estimated using OLS and yields the (K x 1)-vector of parameter coefficients $\hat{\Pi}'_1$. The risk equation 3.2 is estimated using a probit model to obtain the (K x 1)-vector of parameter coefficients $\hat{\Pi}'_2$. Equation 3.1 yields residuals as the difference between observed and fitted market power, $\hat{v}_{1,it} = LI_{it} - \hat{LI}_{it} = LI_{it} - \hat{\Pi}_1' X_{it-1}$. Next, we estimate the structural equations of interest:

$$LI_{it} = \gamma_1 \hat{PD}^*_{it} + \beta_1' X_{1,it-1} + \varepsilon_{1,it} \tag{3.3}$$

$$PD^*_{it} = \gamma_2 LI_{it} + \beta_2' X_{2,it-1} + \theta \hat{v}_{1,it} + \varepsilon_{2,it} \tag{3.4}$$

where $X_{1,it-1}$ and $X_{2,it-1}$ are the exogenous explanatory variables affecting market power and risk, including measures of internationalization. We also specify time-, region-, and banking group-fixed effects. The main qualitative results remain unchanged when we

[17]See also Degryse and Ongena (2001) who use this approach to analyze the relation between the return on investment of banks and the number of creditor relationships.

control for regional macroeconomic developments such as the regional insolvency rate or GDP growth. Equations 3.3 and 3.4 are estimated with OLS and a probit model, respectively. We bootstrap the standard errors because equations 3.3 and 3.4 include generated regressors.

The simultaneity between banks' choices of market power and risk is captured in the following way. In the market-power equation 3.3, we insert fitted values from the probit estimation of the risk equation 3.2. In the risk equation, we insert the residuals from the continuous reduced-form equation $\hat{v}_{it}$ and the true continuous variable $LI_{it}$, i.e. the Lerner index. Rivers and Vuong (1988) recommend this procedure because the probit estimation relies on non-linear estimation techniques. Also, we can explicitly test for exogeneity in the binary equation (see Winkelmann et al., 2006), and a *z-test* of $H_0 : \theta = 0$ indicates whether the true Lerner index $LI_{it}$ is exogenous to the probability of distress.[18]

## 3.4 Empirical Results

Table B.3 provides results of OLS regressions using the Lerner index as dependent variable and Table B.4 provides results of probit models with the distress indicator as dependent variable. Subsequent tables account for the potential endogeneity of the internationalization variable (Tables B.5 and B.6) and portfolio effects when accounting for the correlation of output and equity as well as the distance between destination and home markets (Tables B.7 and B.8).

### 3.4.1 Market Power-Risk Nexus

Columns (1), (2), and (4) of Tables B.3 and B.4 show system estimation results. The two cross terms (indicated by "predicted") are significant and negative. Our *Hypothesis 1 (H1)* states that the relationship between market power and risk is ambiguous. Our results support theoretical models by Allen and Gale (2004) or Martinez-Miera and Repullo (2010), which show that banks with more market power are less risky. Column (3) shows results using bank-specific, but time-invariant *Boone indicators* to measure market power.

[18]Implementing fitted values from the market power equation 3.1 into the structural equation 3.4 instead of the combination of residuals and the true Lerner index would imply to estimate a probit model with an unknown scaling factor. This would not allow for valid inference.

We do not find evidence of a significant relationship between the average sensitivity of profits with respect to marginal cost, i.e. the Boone indicator and risk. A possible problem is that the estimation of the Boone indicator is confined to time series estimation for each individual bank that is based at most on 16 periods. Given this serious limitation, we continue henceforth with Lerner indices as measures of market power. In addition, market power residuals are insignificant in the risk equation. Hence the null hypothesis that market power is exogenous to risk cannot be rejected.[19]

The overall fit of the model is quite good with an adjusted $R^2$ of about 0.37 for the market power equation when using the Lerner index and a pseudo-R2 of 0.29 for the risk equation. All results reported below are based on regressions including the full set of control variables. In unreported regressions, we have excluded individual explanatory variables one-by-one to check whether some of our results might be driven by multicollinearity. This is not the case.

### 3.4.2 Internationalization and Market Power

Our *Hypothesis 2 (H2)* conjectures that internationally more active banks enjoy more market power in their home markets. Consider first the *intensive* margin measured by the foreign to domestic asset share in percent. Column (2) in Table B.3 shows that a higher total share of foreign assets – either through cross-border activities or through foreign branches – has a positive impact on market power, which is in line with *(H2)*. Column (3) shows that this result also holds when specifying the Boone indicator, where a negative sign indicates that a larger *intensive* margin increases a bank's market power. Increasing the foreign asset share by one percent increases Lerner indices by eight basis points, potentially reflecting the ability of internationally active banks to accompany their customers on foreign markets and to lower informational asymmetries through local knowledge. Given an average Lerner index of 23 basis points, this increase is economically substantial and accounts for slightly less than a standard deviation (see Table B.2). At the same time, a one-percent increase in the foreign asset share would be substantial for the average bank, which holds only around 4.4% of its assets abroad (see Table B.1).

[19]We also specified the components of the Lerner index, average revenues and marginal cost, separately as well as plain market shares of banks in terms of total assets. Like the Boone indicator, these measures are insignificant.

However, the mode of foreign market entry is crucial. A key contribution of this paper is the ability to differentiate cross-border activities from operating branches abroad. Therefore, we distinguish the *intensive* margin via cross-border and foreign branch activities in column (4). The result shows that the positive effect of internationalization is driven by maintaining branches, which usually specialize in foreign retail banking. The predicted increase in Lerner indices by 28 basis points for an increasing foreign asset share held through branches amounts to an improvement in market power on the order of one and a half standard deviations (Table B.2). This substantial positive impact on market power is line with the earlier conjecture that engaging in local lending relationships bears information acquisition advantages. Cross-border activities alone, in contrast, do not have a significant impact on market power.

Regarding the *extensive* margin, a larger number of countries reduces market power at home. According to the baseline result, adding an exposure to one additional country reduces Lerner indices by six basis points, i.e. half a standard deviation (Table B.1). This general result holds irrespective of whether we measure market power by Lerner indices (column 2) or Boone indicators (column 3). At first sight, this negative relationship is at odds with *H2*. But the result in column (4) corroborates that the negative effect is driven by an increase in the *extensive* margin in terms of opening foreign branches. This finding is consistent with international economic literature stressing that foreign expansions, especially through foreign direct investment such as branches, is costly, squeezes profit margins, and can thus only be afforded by the largest, most productive banks (Buch et al., 2011a). Not to our surprise, an increase in country exposure by means of branches reduces the average bank's margin. In addition, detrimental markup effects may arise when banks attempt to manage a too far-flung empire that is increasingly complex to control. In unreported regressions, we therefore checked if threshold effects matter. It turns out that increasing international activities beyond a certain number of countries (10 for cross-border assets, five for countries with foreign branches) indeed drive this negative result.

For the control variables, we mostly obtain significant and expected results. Higher *fee income* shares increase market power. Potentially, banks can retain market power by substituting traditional interest income with fee income (DeYoung and Roland, 2001).

*Larger banks* might be able to charge high mark-ups because of their dominant role in output markets, but they may also enjoy market power arising from economies of scale in funding markets. We include a discrete variable to indicate the size quintile of banks' total assets (from 1 to 5).[20] Results show a negative relationship between size and market power, reflecting the fact that smaller banks enjoy market power in regional and niche markets. We measure the degree of specialization of banks' activities using *Hirschman-Herfindahl indices* computed across four asset categories. More specialized banks exhibit larger market power in our sample. Regional concentration (the number of branches in each region and the number of new acquisitions) enhances market power as well.

### 3.4.3 Internationalization and Risk

*Hypothesis 3 (H3)* states that internationally better-diversified banks (via the *extensive margin*) should exhibit less risk whereas the effect of higher exposures (via the *intensive margin*) remains ambiguous. Table B.4 shows the determinants of distress. The key result is that more international banks, in general, are *not* more risky than domestically active banks. Irrespective of whether we consider foreign asset shares held directly across borders and branches jointly (column 2) or if we measure market power with Boone indicators (column 3) both internationalization measures are insignificant. An important difference emerges though when distinguishing the two modes of entry in column (4). We do *not* find evidence for a significant impact of cross-border activities. However, banks that operate *branches* in many foreign countries exhibit lower risk. Entering an additional country via branches reduces the mean distress probability of 7% (Table 2) by 4.7 basis points. This result supports the diversification hypothesis. Having a larger volume of foreign assets held through branches (*intensive margin*), in contrast, increases rather than decreases risk. Taken together, these results suggests that it is indeed the diversification effect that matters, rather than the volume of foreign activities per se. These results are broadly in line with *H2* that the degree of diversification rather than the scale of foreign activities matters for bank risk.

In addition to the internationalization variables, we include a standard vector of control variables to explain distress events with so-called "CAMEL covariates" that capture vari-

[20]Results are qualitatively identical if we use log size instead.

ous aspects of bank-specific risks (capitalization, asset quality, managerial skill, earnings, and liquidity) (see Acharya and Yorulmazer, 2007). We expect more profitable, better capitalized, and banks with a less risky asset portfolio to be less likely to experience a distress event. The signs for the control variables are in line with these expectations and with previous literature (see Dam and Koetter, 2012). Banks with a lower level of hidden reserves and with a lower return on equity are more likely to experience a distress event (see Berger, 1995). In line with e.g. Wheelock and Wilson (1995), higher cost efficiency lowers bank risk. Higher profit efficiency, in turn, has no significant impact on risk. This result corroborates the well-known negative correlation between cost and profit efficiency measures (Bauer et al., 1998). It confirms that both concepts measure different types of optimal behavior of bank managers: the realization of optimal profits seems to involve inevitably higher risk while economizing on costs does not. The core capital ratio, the share of non-performing loans, and the cost-to income ratio have no significant impact

### 3.4.4 Endogeneity of Foreign Assets

The empirical model that we have used so far accounts for the simultaneous determination of market power and risk. But it may not sufficiently address the potential endogeneity of internationalization variables. Endogeneity may arise if banks engaged in risky domestic activities decide to venture abroad in order to offset high domestic risk. In such a case, this bank self-selects into international activities if this rewards them with greater market power at home.

We address the endogeneity concern of foreign assets in three ways: by adopting a proxy for the exogenous component of banks' foreign assets; by using the lagged foreign assets share; and by focusing on banks which have changed their presence abroad. Turning to the first measure, we adopt a methodology from the literature studying the link between trade openness and growth at the country-level. Frankel and Romer (1999) propose to measure the causal impact of trade on growth by employing geographic variables as a (exogenous) instruments for foreign trade. Their method is based on a two-step estimation model. In a first step, a bilateral openness equation is specified. Predicted bilateral openness measures from this equation are then aggregated to obtain a measure of aggregate openness which is only related to a set of exogenous variables. In a second step, predicted openness is used as an instrument in a regression explaining the impact of openness on GDP per capita. This method does not fully suit our panel context because geographic variables used to extract the exogenous component of trade are time-invariant. We thus need a time-varying exogenous explanatory variable for the first-stage regression. In our setup, essentially all foreign macroeconomic variables can be considered exogenous from the individual bank's perspective. Details on the estimation of the exogenous component of foreign assets are given in Appendix B.1.

For the predicted foreign asset share to be a good instrument, it should sufficiently correlate with the actual foreign asset share, which is the case. The correlation between the predicted and the actual foreign asset share at the bank-level (i.e. aggregated across all countries) is 0.58. To eliminate the country dimension in the data, we aggregate foreign asset shares across countries.

Results are reported in Column (2) of Tables B.5 and B.6. They are qualitatively unchanged from those using the actual volume of foreign assets: expansions along the *intensive* margin increase market power, yet, these expansions have no impact on risk. Risk has a negative impact on market power, and the remaining control variables retain their signs and significance. The second way to account for the endogeneity of openness is to make use of the fact that current market power and risk are unlikely to have affected internationalization decisions taken in the past. Hence, we use the foreign assets share lagged by two periods as a right-hand side variable. Results in Column (3) of Tables B.5 and B.6 are very similar to those using the actual or the predicted share of foreign assets. Third, we account for the fact that lagged foreign assets may be persistent. We use information on changes in foreign activities. Exit (number) and Entry (number) are count variables of those countries from which a bank withdrew or into which a bank entered two years before. Results in Columns (4) of Tables B.5 and B.6 show that past exits have a positive impact on market power, consistent with our previous finding that maintaining a foreign presence reduces market power. Past entries, in turn, have no effect although it must be noted that the lag structure of changes in international presence limits the sample considerably and thus might bear only limited information as such.

### 3.4.5 Portfolio Effects

Aside from endogenous foreign activity, the neglect of geographical portfolio effects may be crucial, in particular when considering the relationship of *intensive* and *extensive* margins with risk. Tables B.7 and B.8 give three robustness checks while considering three weighting schemes of portfolio decompositions.

We account for the fact that the mere count of the number of foreign countries (the *extensive* margin) or the volume of activities (the *intensive* margin) do not adequately capture portfolio diversification effects that should matter for the internationalization of banks. To this end, we construct additional explanatory variables that weight foreign activities with the *correlation of stock market returns* or the *correlation of GDP growth* of the respective destination country with that in Germany. Alternatively, we weight foreign activities with the distance between destination countries and Germany. None of these additional variables is significant. At the same time, the result that being active in a larger number of countries has a negative impact on market power remains intact and so does the result that internationalization as such has no significant impact on banks risk. Only the positive impact of internationalization on the market power of banks turns insignificant when including foreign activities weighted by distance or GDP growth.

### 3.4.6 Further Robustness

We conduct a number of additional tests. Results are not reported in the interest of space but available upon request. First, we divided the sample into *weak* and *severe* distress events. In addition to the 240 severe distress events that we consider here, restructuring mergers ordered by the *BaFin (Bundesanstalt für Finanzdienstleistungsaufsicht)* or capital injections by insurance schemes, there have been 26 weaker distress events, such as mandatory announcements by individual banks to the supervisory authority or official warnings by the BaFin. As a robustness check, we therefore split the sample into weak and severe distress events when estimating the system of equations. Results are qualitatively identical compared to the reported ones, in particular as regards the mutual negative impact of market power on risk. Again, there is no significant impact of internationalization on risk.

Second, we used the *z-score* described in Section 3.2.3 as an alternative risk measure. This alternative risk measure confirms the negative correlation between risk and market power, but the impact of predicted Lerner indices on the z-score are sometimes insignificant. The impact of internationalization on market power is mostly replicated. As before, internationalization has no significant impact on risk. Results for the remaining explanatory variables do not change.

Third, we split the sample by size and banking groups. Sub-samples for five size categories reveal differences across banks. For all but the mid-sized banks, a higher volume of cross-border assets has a positive effect. The impact of expansions along the *extensive* margin on market power at home varies across banks of different size. For the smallest 40% of the banks, internationalization has an insignificant (negative) effect. For the mid-sized and large banks, internationalization has a positive effect. The negative and significant impact for the full sample is driven by the "upper-middle" sized banks in the fourth size quintile. One interpretation of this non-linear effect is that these banks are too large to gain a competitive edge from foreign expansions as the mid-sized banks do, but that they are too small to reap the true scale economies as the very large banks do.

Finally, we estimate the baseline model for the different banking groups in Germany separately. Traditionally, German banks differ in their degree of internationalization because of different business models. Large commercial banks have a long history in foreign markets whereas savings and cooperative banks are domestically oriented. We split the sample by type of bank to account for these differences. The largest group of banks are the cooperatives, followed by the savings banks, and the commercial banks. The result that market power declines when banks are active in many countries (higher *extensive* margin) is a feature of savings and cooperative banks, but not for commercial banks. The positive effect of a large volume of activities (higher *intensive* margin), in turn, is present in the sub-samples of commercial and savings but not of cooperative banks. Hence, in terms of market power, commercial banks unequivocally gain from globalization while cooperative banks lose. In terms of risk effects of internationalization, we do not find significant effects for commercial and savings banks, corroborating the results obtained for the full sample.

## 3.5 Conclusions

We use a simultaneous two-equation model to analyze how internationalization affects the relationship between market power and risk in the domestic German banking market between 2003 and 2006. Based on detailed data of the Bundesbank, we estimate bank-specific market power, observe official distress events to measure individual risk and distinguish between two foreign entry modes: cross-border asset holdings and operating branches abroad. We test three hypotheses that link bank internationalization (measured by *extensive* and *intensive* margins), their market power (proxied by Lerner indices) and risk (captured by distress events).

First, we hypothesize that the relationship between market power and risk is a priori ambiguous on theoretical grounds. After accounting for the simultaneous determination of market power and risk, and conditioning on international activities, we find a negative correlation between market power and risk. This result is robust to the inclusion of size as a separate covariate. Indeed, when we control for other bank-specific characteristics, we find that banks see their market power decline when growing in size. Our result on the negative relationship between market power and risk suits theoretical models that emphasize the importance of market power to build up profitability buffers against shocks.

Second, we hypothesize that banks with international activities enjoy more market power in domestic markets because of larger average revenues and lower marginal costs. Larger average revenues might ensue from offering banking services to more markets or the ability to follow domestic customers abroad. Lower marginal costs might reflect a wider range of expertise in generating private information from larger, geographically diversified customer pools and productivity gains. We distinguish between two measures of international activity, the *intensive* and the *extensive* margin.

The *intensive* margin equals the share of foreign assets relative to total assets. We find that the *intensive* margin has a significantly positive effect on Lerner mark-ups. This result remains intact (i) when measuring bank competition with Boone indicators, (ii) when accounting for endogenous foreign market entry using lagged exposures and the exogenous component of foreign exposures (see Frankel and Romer, 1999), and (iii) when accounting for the correlation of equity returns between destination countries and Germany. The *intensive* margin becomes insignificant though when considering historical entry and exit behavior to control for endogenous exposures and when using real output correlations and distances instead of equity returns to weigh foreign exposures. We do not find evidence for a significant relationship between foreign asset shares and Lerner index components, neither for average revenues, nor for marginal costs, nor for simpler measures of market power such as domestic market shares. A key contribution of this paper is the ability to differentiate cross-border activities from operating branches abroad. In this light, we find that the significant relationship between the *intensive* margin and the Lerner index is driven by exposures arising from foreign branches rather than cross-border activities. Accounting for this usually omitted channel of international bank activity in the literature is thus important. Sample splits by banking group show that commercial and savings banks exhibit higher Lerner markups in response to a higher *intensive* margin while cooperative banks exhibit lower market power.

The *extensive* margin reflects the number of destination countries in which a banks reports any operations. Across various specifications to control for alternative measures of market power, endogenous entry, and destination country correlation with Germany, we find a negative relationship between market power and the *extensive* margin. This result is also driven by exposures arising from foreign branches rather than cross-border activities. Managing a too far-flung, complex empire may become increasingly difficult and only the largest, most productive banks are able to reap the profits at home from costly acquired additional information abroad.

Third, we hypothesize that the relationship between the *extensive* margin and bank risk is negative, whereas it is ambiguous regarding the *intensive* margin. Empirical evidence on the impact of *extensive* and *intensive* margins on risk is rather weak. Again, a key contribution is our ability to differentiate cross-border activities from operating branches abroad. For the entire sample of banks, a higher *extensive* margin reduces risk via foreign branches but not cross-border activity. We do also find a positive effect of higher business volumes of foreign branches on risk, but not of cross-border transactions. Diversification benefits thus seem unlikely to materialize for small, unsophisticated banks and to be over-compensated by the costs of maintaining too large international branch networks. This result underpins the importance to distinguish the channels of internationalization, cross-border versus foreign branch activity. Generally speaking, the relationship between bank internationalization and risk is weak and often turns insignificant when accounting for alternative market power measures, endogenous entry, and correlation between Germany and destination countries.

Overall, the results suggest that the potential benefits from internationalization in terms of a better risk-return tradeoff are rather elusive. Increasing bank internationalization by means of intensifying existing country exposures (the *intensive* margin) increases banks' mark-ups, which in turn reduces risk. However, a bank raising the volume of foreign branch operations also increases its risk. Internationalization by means of servicing more countries (*extensive* margin) reduces mark-ups as well as risk if the bank enters these markets by operating branches.

Understanding the market power-risk tradeoff for internationally active banks is of key importance for policymakers. Given the global financial crisis, the benefits of international banking in terms of enhanced mark-ups which stabilize the banking system seem to outweigh the relatively weak impact of bank internationalization on bank risk that prevails in this sample. The potentially detrimental effects on risk through networks of foreign branches point out that international integration not only brings about diversification benefits but also does it expose these banks to risks that might be systemically most relevant. Designing appropriate policy tools requires further insights into the relationships between all modes of bank internationalization and bank risk .

## Contribution

Similar to the first paper, I actively participated in all stages of developing this paper, from contributing ideas, data preparation to interpreting results and ultimately writing and revising the text. In what follows I consider three examples of my contribution in more detail by.

Section 3.3 presents our empirical model. Besides concerns about the simultaneity of risk and market power, we have to tackle the problem of possible endogeneity related to our measures of internationalization. Our setup of one binary and one continuous endogenous variable requires a complex estimator because probit models rely on non-linear estimation methods. Any implemented STATA program was not able to test for the exogeneity in the binary equation which lead me to consider and implement the approach of Rivers and Vuong (1988). They suggest jointly inserting fitted residuals from the first stage and the true Lerner index into the risk equation on the second stage.

Besides, I was involved in tailoring the Frankel-Romer approach to our specific context. Their method draws on a two-step estimation model to account for the endogeneity of internationalization. Our panel dataset, yet, does not suit their setup. For this reason, we had to find time-varying exogenous covariates to enter the first stage. Appendix B.1 elaborates on how to adjust the suggestions of Frankel and Romer (1999) to our specific context of more dimensions in the data setup.

Third, I contributed to the construction of adequate weighting schemes of foreign exposures. The aim was to enrich an explanatory variable of internationalization by the degree of foreign and domestic correlation of macroeconomic factors. We use the portfolio of foreign country exposures respectively along the *intensive* and *I* margin and construct weights for each country. With respect to these weights, we include correlations between foreign and German stock market returns or GDP growth. Taking the inverse of these correlations, we weight down exposures with high correlations. Besides, we developed a weighting scheme by distances.

In brief, my core contributions relate to the empirical aspects of the paper, ranging from developing the appropriate estimation techniques to constructing adequate instruments and weighting schemes. However, I was also involved in all general tasks.

# Appendix B

# Do banks benefit from internationalization?

## B.1 Technical Appendix: Exogeneity of Foreign Assets

This appendix describes how we estimate the exogenous component of foreign assets based on the methodology proposed by Frankel and Romer (1999). Our modified first stage Frankel-Romer regression looks as follows:

$$FA_{ijt} = a_0 + a_{i,1}Dist_j + a_{i,2}GDP^*_{jt} + \varepsilon_{ijt} \tag{B.1}$$

where $FA_{ijt}$ is the share of foreign assets across modes relative to total assets of bank $i$ held in country $j$ in year $t$, $Dist_j$ is the geographic distance between Germany and country $j$, $GDP^*_{jt}$ is foreign GDP which is exogenous to the individual bank $i$, and $\varepsilon_{ijt}$ is an error term which captures the bank-specific determinants of foreign assets. We estimate Equation B.1 bank-by-bank using OLS to obtain bank-specific regression coefficients.

The predicted values from this equation are used to obtain a bank-specific instrument of bilateral openness. Re-writing B.1 in matrix form $FA_{ijt} = \mathbf{a'_i}\mathbf{\Theta_{jt}} + \varepsilon_{ijt}$ where $\mathbf{a}'_i$ is the vector of coefficients and $\Theta_{jt}$ is the vector of right-hand-side variables, bank $i$'s overall predicted foreign assets are given by $F\hat{A}_{ijt} = \hat{\mathbf{a'_i}}\mathbf{\Theta_{jt}}$.

## B.2 Data Appendix

All bank data are obtained from unconsolidated balance sheets, profit and loss accounts, and audit reports reported annually by all banks to the *Deutsche Bundesbank*. We use unconsolidated financial statements of unitary banks. These statements contain information on domestic banks, including their foreign branches. Variables used for, both the productivity estimation and the CAMEL vector are corrected for outliers by truncating at the 1st and 99th percentiles, respectively. Level variables are deflated with the consumer price index. Descriptive statistics of all variables are given in Table B.1.

**Bank-level variables**

**Acquisitions** The number of acquisitions per regional agglomeration area.

**Assets** Gross total assets. An indicator variable based on the size distribution of total assets per year ranging from 1 (low) to 5 (high).

**Banking Group** An indicator variable ranging from 1 to 4 for large banks, regional commercial, regional savings, and cooperative banks. "Large" banks comprise the head institutions of the savings (*Landesbanken*) and cooperative bank sector as well as the largest commercial banks. "Commercial banks" are privately owned, but not necessarily publicly listed banks. "Savings banks" are (local) government owned regional banks. "Cooperative banks" are mutually owned regional banks.

**Branches** The number of domestic branches per bank relative to total assets.

**Capitalization** Core capital in percent of gross total assets.

**Cost efficiency** Cost efficiency obtained from a latent stochastic cost frontier analysis with two technology regimes.

**Cost-income ratio** Personnel expenditure in percent of total administrative cost.

**Customer loans** Loans to corporate customers and individuals.

**Equity** Gross total equity in EUR millions.

**Herfindahl index (output categories)** Diversification indicator across four output categories of banks, interbank loans, customer loans, bonds and stocks, and notional values of granted guarantees and credit commitments, calculated as the sum of squared shares of each product category.

**Interbank loans** Loans to banks and other depository institutions.

**Loan-loss-provisions** Stock of loan-loss provisions in percent of gross total loans.

**Non-performing loans** Loans with latent risks according to central bank auditors in percent of total audited loans.

**Off-balance sheet items** Granted credit guarantees and commitments.

**Physical capital** Fixed assets including IT-capital stock in EUR millions.

**Profit efficiency** Profit efficiency obtained from a latent stochastic profit frontier analysis with two technology regimes.

**Publicly incorporated banks** Indicator variable equal to 1 if the bank is publicly incorporated, either as joint stock or public limited company (*Aktiengesellschaft* (*AG*); *Kommanditgesellschaft auf Aktien* (*KGaA*); *Gesellschaft mit beschraenkter Haftung* (*GmbH*)).

**Reserves** Hidden reserves according to §340f of the German commercial code in percent of gross total assets.

**Return on equity (ROE)** Operating result including net interest, fee, commission and trading income in percent of equity capital.

**Securities** Bonds and stocks.

**Share of fee income** Provision and fee income relative to total operating gross revenues.

**Data on Bank Risk**

To measure the soundness of the German banking sector, we use confidential information from the distress database of the *Deutsche Bundesbank* for individual banks at an annual frequency. These data allow for a distinction between different distress categories that differ in terms of severity of distress observed:

**Weak distress events** Mandatory announcements by individual banks to the supervisory authority (Distress Category I) and official warnings by the *Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin)* (Distress Category II),

**Severe distress events** Direct interventions into the ongoing business of a bank by the *BaFin* (Distress Category III), and all events that reflect the disappearance of a bank from active business operations such as closure of a bank or restructuring mergers (Distress Category IV).

**External Position Report**

Data on the international assets of German banks are taken from the "External Position Report" of the *Deutsche Bundesbank*. They are confidential and can be used on the premises of the Bundesbank only.

**International assets** Loans and advances to banks, companies, governments, bonds and notes, foreign shares and other equity, participation abroad, denominated or converted into Euro. Irrevocable credit commitments are included but other off-balance sheet items are not. For a more detailed description of this data base see Fiorentino et al. (2010).

**Branches and subsidiaries** Foreign affiliates of German parent banks. Branches do not have an independent legal status, whereas subsidiaries do. We attribute assets held by affiliates to the country in which they are located.

**List of countries** United Arab Emirates, Argentina, Austria, Australia, Belgium, Bulgaria, Brazil, Canada, Switzerland, Chile, China, Cyprus, Czech Republic, Denmark, Estonia, Egypt, Spain, Finland, France, Greece, Hong Kong, Hungary, Indonesia, Ireland, Israel, India, Italy, Japan, South Korea, Cayman Islands, Lithuania, Luxemburg, Latvia, Morocco, Malta, Mexico, Malaysia, Netherlands, Norway, New Zealand, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Sweden, Singapore, Slovenia, Slovakia, Thailand, Turkey, Taiwan, Ukraine, United Kingdom, United States, Vietnam, South Africa.

## B.3 Tables and Figures

Table B.1: Descriptive Statistics: Internationalization

| | Full Sample (7118 bank-year observations) | | | | Banks with branches (138 bank-year observations) | | | |
|---|---|---|---|---|---|---|---|---|
| | mean | sd | p1 | p99 | mean | sd | p1 | p99 |
| **I. Number of countries (extensive margin)** | | | | | | | | |
| Cross-border plus branches | 13.58 | 9.425 | 1 | 54 | 41.57 | 21.03 | 0 | 71 |
| Cross-border | 13.61 | 9.455 | 2 | 54 | 42.72 | 20.06 | 7 | 71 |
| Branches | 0.087 | 1.084 | 0 | 1 | 4.475 | 6.389 | 1 | 32 |
| **II. Foreign assets / total assets (intensive margin)** | | | | | | | | |
| Cross-border plus branches | 0.044 | 0.076 | 0 | 0.434 | 0.347 | 0.231 | 0.009 | 0.828 |
| Cross-border | 0.042 | 0.066 | 0 | 0.322 | 0.241 | 0.185 | 0.005 | 0.958 |
| Branches | 0.002 | 0.026 | 0 | 0.076 | 0.120 | 0.143 | 0.000 | 0.640 |
| Total assets | 2,090 | 11,400 | 28 | 36,600 | 55,000 | 56,800 | 198 | 133,000 |

Notes: This table gives the descriptive statistics for the extensive and the intensive margin of banks' foreign activities. The *extensive* margin reported in Panel I is a count variable measuring the number of destination countries in which banks hold foreign assets and the number of foreign branches of a bank. The *intensive* margin reported in Panel II gives the foreign assets relative to the total assets of a bank. We distinguish the assets held in the cross-border mode and through foreign branches. We report each of these measures for all banks included in the sample as well as for the banks with foreign branches separately.

Table B.2: Descriptive Statistics: Regression Variables

| | Full Sample (7118 bank-year observations) | | | | Banks with branches (138 bank-year observations) | | | |
|---|---|---|---|---|---|---|---|---|
| | mean | sd | p1 | p99 | mean | sd | p1 | p99 |
| **Market Power** | | | | | | | | |
| Lerner index | 22.67 | 11.69 | -9.174 | 51.56 | 14.91 | 20.91 | -32.61 | 57.47 |
| Boone indicator | -0.89 | 4.41 | -4.60 | 2.11 | -0.64 | 1.10 | -3.33 | 2.10 |
| **Risk** | | | | | | | | |
| Distress frequency | 0.04 | 0.19 | 0 | 1 | 0.07 | 0.26 | 0 | 1 |
| Z-score | -4.40 | 4.04 | -17.65 | 0.92 | -3.734 | 4.59 | -23 | 1.268 |
| **Explanatory variables: Market Power** | | | | | | | | |
| Fee income | 12.30 | 5.41 | 2.30 | 33.44 | 12.11 | 11.58 | 1.49 | 57.80 |
| Size quintile | 3.06 | 1.39 | 1.00 | 5.00 | 4.75 | 0.69 | 2.00 | 5.00 |
| Herfindahl (output cateogories) | 46.32 | 8.91 | 29.42 | 71.56 | 38.16 | 14.92 | 25.58 | 86.93 |
| Publicly incorporated | 0.04 | 0.20 | 0.00 | 1.00 | 0.50 | 0.50 | 0.00 | 1.00 |
| Branches | 28.87 | 21.24 | 0.17 | 101.10 | 8.10 | 17.42 | 0.00 | 88.97 |
| Acquisitions | 1.93 | 2.48 | 0.00 | 12.00 | 4.86 | 4.40 | 0.00 | 14.00 |
| **Explanatory variables: Risk** | | | | | | | | |
| Core capital ratio | 5.64 | 2.19 | 2.59 | 11.20 | 4.75 | 3.77 | 1.18 | 17.97 |
| Reserves | 1.51 | 1.04 | 0.00 | 4.58 | 0.29 | 0.36 | 0.00 | 1.64 |
| Customer loan share | 58.86 | 12.90 | 21.95 | 83.60 | 44.03 | 20.44 | 10.74 | 95.94 |
| Non-performing loans | 8.75 | 7.01 | 0.30 | 32.86 | 8.05 | 12.82 | 0.22 | 66.56 |
| Cost-income ratio | 29.38 | 6.36 | 7.15 | 42.67 | 15.97 | 12.15 | 2.49 | 44.94 |
| Return on equity | 11.60 | 11.57 | -23.29 | 34.42 | 9.63 | 17.83 | -46.39 | 58.03 |
| Cost efficiency | 84.20 | 9.98 | 54.00 | 98.34 | 78.76 | 18.72 | 34.05 | 99.36 |
| Profit efficiency | 73.17 | 13.24 | 25.19 | 92.38 | 63.33 | 22.93 | 1.63 | 94.27 |
| **Portfolio effects: Extensive margin** | | | | | | | | |
| Average growth correlation | 1 | 0.163 | 0.273 | 0.891 | 0.447 | 0.154 | 0.261 | 0.836 |
| Average stock market correlation | 1 | 0.132 | 0.345 | 0.929 | 0.492 | 0.158 | 0.214 | 0.875 |
| Average distance | 2555 | 929 | 617 | 4955 | 3934 | 1043 | 1095 | 5037 |
| **Portfolio Effects: Intensive margin** | | | | | | | | |
| Weights = growth correlations | 0.029 | 0.047 | 0 | 0.266 | 0.216 | 0.140 | 0.003 | 0.474 |
| Weights = stock return correlations | 0.003 | 0.004 | 0 | 0.018 | 0.010 | 0.011 | 0 | 0.051 |
| Distance weights | 85 | 209 | 0 | 942 | 892 | 848 | 8 | 2786 |

Notes: This table gives the descriptive statistics for explanatory variables used in the regressions. The total number of observations (bank-year) is 7,118. For detailed data definitions see the Appendix B.2. The Lerner index is the mark-up between average revenues and marginal costs, scaled by average revenues. Details are given in Section 3.2 of the main text.

Table B.3: Baseline Regression Results: (a) Market Power

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent variable: | Lerner index | Lerner index | Boone | Lerner index |
| Market Power as: | | | indicator | |
| Predicted risks as covariate | | | | |
| No. of destinations (all) | | -0.059** | 0.070** | |
| | | (0.025) | (0.036) | |
| Foreign asset share (all) | | 8.335** | -17.487** | |
| | | (3.420) | (8.048) | |
| No. of destinations (cross-border) | | | | -0.049 |
| | | | | (0.031) |
| Foreign assets (cross-border) / total assets | | | | 4.367 |
| | | | | (3.711) |
| No. of destinations (branches) | | | | -0.668** |
| | | | | (0.279) |
| Foreign assets (branches) / total assets | | | | 28.871*** |
| | | | | (7.390) |
| Risk (predicted) | -4.739*** | -4.730*** | -0.208 | -4.729*** |
| | (0.198) | (0.181) | (0.193) | (0.207) |
| Fee income | 0.220*** | 0.228*** | -0.004 | 0.228*** |
| | (0.043) | (0.043) | (0.037) | (0.046) |
| Size quintile | -1.132*** | -0.904*** | -0.536*** | -0.930*** |
| | (0.125) | (0.147) | (0.139) | (0.146) |
| Herfindahl | 0.097*** | 0.103*** | -0.085** | 0.099*** |
| | (0.014) | (0.015) | (0.034) | (0.018) |
| Publicly incorporated | -6.039*** | -6.151*** | -1.390** | -6.428*** |
| | (1.353) | (1.245) | (0.662) | (1.413) |
| Branches | 0.008 | 0.007 | -0.012*** | 0.008 |
| | (0.009) | (0.008) | (0.002) | (0.009) |
| Acquisitions | 0.095* | 0.078 | 0.001 | 0.089* |
| | (0.055) | (0.051) | (0.023) | (0.047) |
| Constant | 16.183*** | 15.925*** | 4.169** | 16.244*** |
| | (2.165) | (2.178) | (1.949) | (2.427) |
| Observations | 7118 | 7118 | 7081 | 7118 |
| $R^2$ | 0.373 | 0.376 | 0.097 | 0.378 |

Table B.4: Baseline Regression Results: (b) Risk as Distress indicator

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent variable: Distress indicator | | | | |
| Market Power as covariate: | Lerner index | Lerner index | Boone indicator | Lerner index |
| No. of destinations (all) | | 0.0001 | 0.0002 | |
| | | (0.0001) | (0.0001 ) | |
| Foreign asset share | | 0.0050 | 0.0028 | |
| | | (0.0202) | (0.0161) | |
| No. of destinations (cross-border) | | | | 0.0002 |
| | | | | (0.0001) |
| Foreign assets (cross-border) / total assets | | | | -0.0001 |
| | | | | (0.0268) |
| No. of destinations (branches) | | | | -0.0047** |
| | | | | (0.0022) |
| Foreign assets (branches) / total assets | | | | 0.0876* |
| | | | | (0.0482) |
| Market power (predicted) | -0.0013** | -0.0010** | -0.0001 | -0.0009** |
| | (0.0005) | (0.0005) | (0.0006) | (0.0004) |
| Market power residuals | 0.0008 | 0.0005 | 0.0004 | 0.0005 |
| | (0.0005) | (0.0005) | (0.0006) | (0.0004) |
| Core capital ratio | 0.0009 | 0.0007 | -0.0005 | 0.0007 |
| | (0.0009) | (0.0007) | (0.0009) | (0.0006) |
| Reserves | -0.0123*** | -0.0129*** | -0.0160*** | -0.0127*** |
| | (0.0015) | (0.0019) | (0.0021) | (0.0015) |
| Customer loan share | 0.0002** | 0.0002** | 0.0001 | 0.0002* |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Non-performing loans | 0.0000 | 0.0000 | 0.0002 | 0.0000 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Cost-income ratio | 0.0004* | 0.0003 | 0.0002 | 0.0003* |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Return on equity | -0.0003** | -0.0003** | -0.0005*** | -0.0003*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Cost efficiency | -0.0002** | -0.0002** | -0.0004*** | -0.0002** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Profit efficiency | 0.0001 | 0.0001 | -0.0000 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Observations | 7,118 | 7,118 | 7,118 | 7,118 |
| Pseudo_$R^2$ | 0.292 | 0.292 | 0.275 | 0.295 |

Notes: Tables B.3 and B.4 give regression results from estimating the probability of distress and the market power of banks (Lerner index) simultaneously, as described in Section 3.3. Estimations of the Lerner index in Table B.3 use OLS, estimations of the probability of distress in Table B.4 use a probit model. All explanatory variables are lagged by one period. Dummies for different banking groups, time, and regional fixed effects are included but not reported. Internationalization is measured through the number of countries in which a bank is present (extensive margin) and the share of foreign assets in total assets (intensive margin). Table B.3 depicts coefficients with standard errors in brackets, Table B.4 reports marginal effects with standard errors in brackets. ***, **, * = significant at the 1%, 5%, 10%-level drawing on bootstrapped standard errors.

Table B.5: Endogeneity of Foreign Status: (a) Market power (Lerner index)

| | (1) Baseline | (2) Frankel-Romer | (3) Two year lag | (4) Lagged number of entries and exits |
|---|---|---|---|---|
| No. of countries, t-1 | -0.059** | | | |
| | (0.023) | | | |
| Foreign assets / total assets t-1 | 8.335** | | | -1.220 |
| | (3.864) | | | (4.294) |
| No. of countries, t-2 | | -0.079*** | -0.081*** | |
| | | (0.028) | (0.024) | |
| Foreign assets / total assets t-2 | | | 8.611** | |
| | | | (3.840) | |
| Entry (0/1) (t-2) | | | | |
| Exit (0/1) (t-2) | | | | |
| Entry (number) (t-2) | | | | -0.037 |
| | | | | (0.097) |
| Exit (number) (t-2) | | | | 0.217*** |
| | | | | (0.072) |
| Foreign / total assets (Frankel/Romer) | | 5.980* | | |
| | | (3.073) | | |
| Risk (predicted) | -4.730*** | -4.951*** | -4.944*** | -5.139*** |
| | (0.183) | (0.272) | (0.289) | (0.370) |
| Fee income | 0.228*** | 0.231*** | 0.233*** | 0.187*** |
| | (0.038) | (0.041) | (0.048) | (0.050) |
| Size quintile | -0.904*** | -0.882*** | -0.865*** | -0.852*** |
| | (0.141) | (0.197) | (0.192) | (0.193) |
| Herfindahl | 0.103*** | 0.104*** | 0.105*** | 0.115*** |
| | (0.019) | (0.019) | (0.021) | (0.021) |
| Publicly incorporated | -6.151*** | -5.252*** | -5.309*** | -4.517** |
| | (1.323) | (1.359) | (1.547) | (1.789) |
| Branches | 0.007 | 0.012 | 0.012 | 0.046*** |
| | (0.010) | (0.014) | (0.014) | (0.011) |
| Acquisitions | 0.078 | 0.075 | 0.068 | -0.051 |
| | (0.052) | (0.065) | (0.075) | (0.103) |
| Constant | 15.925*** | 14.897*** | 14.789*** | 10.580*** |
| | (1.994) | (2.944) | (2.296) | (2.549) |
| Observations | 7118 | 5219 | 5219 | 3018 |
| R-squared | 0.376 | 0.378 | 0.379 | 0.418 |

Table B.6: Endogeneity of Foreign Status: (b) Risk as Distress indicator

| | (1) Baseline | (2) Frankel-Romer | (3) Two year lag | (4) Lagged number of entries and exits |
|---|---|---|---|---|
| No. of countries, t-1 | 0.0001 | | | |
| | (0.0001) | | | |
| Foreign assets / total assets t-1 | 0.0050 | | | -0.0072 |
| | (0.0162) | | | (0.0150) |
| No. of countries, t-2 | | 0.0001 | 0.0001 | |
| | | (0.0001) | (0.0001) | |
| Foreign assets / total assets t-2 | | | 0.0034 | |
| | | | (0.0198) | |
| Entry (0/1) (t-2) | | | | |
| Exit (0/1) (t-2) | | | | |
| Entry (number) (t-2) | | | | 0.0000 |
| | | | | (0.0004) |
| Exit (number) (t-2) | | | | 0.0005 |
| | | | | (0.0004) |
| Foreign / total assets (Frankel/Romer) | | 0.0013 | | |
| | | (0.0131) | | |
| Lerner (predicted) | -0.0010** | -0.0006 | -0.0006 | -0.0008 |
| | (0.0005) | (0.0006) | (0.0005) | (0.0007) |
| Lerner residuals | 0.0005 | 0.0003 | 0.0003 | 0.0005 |
| | (0.0005) | (0.0006) | (0.0005) | (0.0007) |
| Core capital ratio | 0.0007 | 0.0006 | 0.0006 | 0.0006 |
| | (0.0007) | (0.0008) | (0.0008) | (0.0015) |
| Reserves | -0.0129*** | -0.0093*** | -0.0094*** | -0.0080*** |
| | (0.0016) | (0.0021) | (0.0020) | (0.0025) |
| Customer loan share | 0.0002* | 0.0001 | 0.0001 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Non-performing loans | 0.0000 | -0.0000 | -0.0000 | -0.0000 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0002) |
| Cost-income ratio | 0.0003 | 0.0002 | 0.0002 | 0.0002 |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Return on equity | -0.0003*** | -0.0004*** | -0.0004** | -0.0003* |
| | (0.0001) | (0.0001) | (0.0002) | (0.0002) |
| Cost efficiency | -0.0002*** | -0.0003*** | -0.0003*** | -0.0002 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Profit efficiency | 0.0001 | 0.0000 | 0.0000 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Observations | 7118 | 5219 | 5219 | 3018 |

Notes: Tables B.5 and B.6 gives regression results for simultaneously estimating the probability of distress and the market power of banks (Lerner index) as described in Section 3.3 Estimations of the Lerner index in Table B.5 use OLS, estimations of the probability of distress in Table B.6 use a probit model. All explanatory variables are lagged by one period. Dummies for different banking groups, time, and regional fixed effects are included but not reported. *Number of countries* is the number of countries in which the bank has cross-border activities or holds foreign branches. *Foreign assets / total assets* is the sum of cross-border and branch assets. *Entry (0/1)* is a dummy variable which is equal to one if a bank has increased the number of foreign countries in which it is active, *Exit (0/1)* is a dummy variable which is equal to one if a bank has lowered the number of countries. *Exit (number)* and *Entry (number)* are the corresponding variables using the absolute value of the count of countries from which a bank has withdrawn or into which a bank has newly expanded. *Internationalization* is measured through the number of countries in which a bank is present (extensive margin) and the share of foreign assets in total assets (intensive margin). Table B.5 depicts standardized coefficients in brackets, Table B.6 reports marginal effects and standard errors on brackets. ***, **, * = significant at the 1%, 5%, 10%-level drawing on bootstrapped standard errors.

Table B.7: Including Portfolio Effects: (a) Market power (Lerner index)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| No. of destination countries (branches + cross-border) | -0.059** | -0.068** | -0.083*** | -0.052* |
| | (0.025) | (0.030) | (0.029) | (0.027) |
| Foreign assets (cross-border + branches) / total assets | 8.335*** | 8.448 | 10.831** | 9.611 |
| | (2.948) | (7.865) | (4.883) | (8.134) |
| Average growth correlation | | -1.266 | | |
| | | (1.137) | | |
| Weighted foreign assets / total assets (weights = growth correlations) | | -0.232 | | |
| | | (12.229) | | |
| Average stock market correlation | | | -2.302 | |
| | | | (1.977) | |
| Weighted foreign assets / total assets (weights = stock market correlations) | | | -64.448 | |
| | | | (63.987) | |
| Average distance | | | | -0.000 |
| | | | | (0.000) |
| Weighted foreign assets / total assets (weights = distance weights) | | | | -0.001 |
| | | | | (0.003) |
| Risk (predicted) | -4.730*** | -4.738*** | -4.745*** | -4.754*** |
| | (0.180) | (0.168) | (0.181) | (0.172) |
| Fee income | 0.228*** | 0.230*** | 0.235*** | 0.225*** |
| | (0.041) | (0.042) | (0.043) | (0.040) |
| Size quintile | -0.904*** | -0.893*** | -0.913*** | -0.911*** |
| | (0.131) | (0.156) | (0.151) | (0.147) |
| Herfindahl | 0.103*** | 0.104*** | 0.104*** | 0.103*** |
| | (0.023) | (0.017) | (0.018) | (0.015) |
| Publicly incorporated | -6.151*** | -6.134*** | -6.218*** | -6.136*** |
| | (1.272) | (1.384) | (1.185) | (1.197) |
| Branches | 0.007 | 0.007 | 0.008 | 0.007 |
| | (0.010) | (0.010) | (0.011) | (0.010) |
| Acquisitions | 0.078 | 0.076 | 0.083* | 0.076 |
| | (0.055) | (0.066) | (0.049) | (0.049) |
| Constant | 15.925*** | 16.537*** | 17.842*** | 16.261*** |
| | (2.137) | (2.211) | (2.672) | (2.348) |
| Observations | 7,118 | 7,118 | 7,116 | 7,118 |
| $R^2$ | 0.376 | 0.377 | 0.377 | 0.377 |

Table B.8: Including Portfolio Effects: (b) Risk as Distress indicator

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| No. of destination countries (branches + cross-border) | 0.0001 | 0.0001 | 0.0000 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Foreign assets (cross-border + branches) / total assets | 0.0050 | 0.0094 | 0.0227 | 0.0249 |
| | (0.0178) | (0.0302) | (0.0271) | (0.0299) |
| Average growth correlation | | -0.0030 | | |
| | | (0.0078) | | |
| Weighted foreign assets / total assets (weights = growth correlations) | | -0.0079 | | |
| | | (0.0432) | | |
| Average stock market correlation | | | -0.0039 | |
| | | | (0.0102) | |
| Weighted foreign assets / total assets (weights = stock return correlations) | | | -0.5154 | |
| | | | (0.4175) | |
| Average distance | | | | -0.0000 |
| | | | | (0.0000) |
| Weighted foreign assets / total assets (distance weights) | | | | -0.0000 |
| | | | | (0.0000) |
| Lerner (predicted) | -0.0010 | -0.0010* | -0.0008 | -0.0010* |
| | (0.0006) | (0.0006) | (0.0006) | (0.0005) |
| Lerner residuals | 0.0005 | 0.0005 | 0.0003 | 0.0005 |
| | (0.0006) | (0.0005) | (0.0006) | (0.0006) |
| Core capital ratio | 0.0007 | 0.0007 | 0.0004 | 0.0005 |
| | (0.0009) | (0.0007) | (0.0007) | (0.0008) |
| Reserves | -0.0129*** | -0.0129*** | -0.0132*** | -0.0128*** |
| | (0.0020) | (0.0024) | (0.0018) | (0.0016) |
| Customer loan share | 0.0002** | 0.0002* | 0.0001** | 0.0002** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Non-performing loans | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Cost-income ratio | 0.0003* | 0.0003* | 0.0003 | 0.0003* |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Return on equity | -0.0003** | -0.0003** | -0.0003** | -0.0003** |
| | (0.0001) | (0.0001) | (0.0002) | (0.0002) |
| Cost efficiency | -0.0002** | -0.0002** | -0.0002*** | -0.0002** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Profit efficiency | 0.0001 | 0.0001 | 0.0000 | 0.0001 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Observations | 7,118 | 7,118 | 7,116 | 7,118 |

Notes: Tables B.7 and B.8 give regression results from simultaneously estimating the probability of distress and the market power of banks (Lerner index) as described in Section 3.3. Estimations of the Lerner index in Table B.7 use OLS, estimations of the probability of distress in Table B.8 use a probit model. All explanatory variables are lagged by one period. Dummies for different banking groups, time, and regional fixed effects are included but not reported. *Internationalization* is measured through the number of countries in which a bank is present (extensive margin) and the share of foreign assets in total assets (intensive margin). Table B.7 depicts coefficients and standard errors in brackets, Table B.8 reports marginal effects and standard errors in brackets. Average growth correlations, average stock market correlations, and average distances are averages for the countries in which a particular bank is active in a particular year. Weighted foreign assets relative to total assets use GDP correlations, stock market correlations, and distance weights, respectively. ***, **, * = significant at the 1%, 5%, 10%-level drawing on bootstrapped standard errors.

# 4

# Risky Adjustments or Adjustments to Risks: Decomposing Bank Leverage[1]

The Lehman collapse of September 2008 marks the outset of the banking crisis and has induced banks to substantially restructure their balance-sheets. Uncertainty paralyzed the interbank market and lead to a fundamental change in bank funding conditions. This paper sheds light on the dynamics of banks' liabilities from a short- and long-run perspective. From a long-run perspective, it examines how banks reallocate various liabilities in response to fundamental ruptures in their funding conditions. From a short-run perspective, it examines which liability components adjust for short-run deviations from long-run liability ratios that, in turn, are induced by changes in financial market risks.

If banks exhibit constant liability ratios of for instance equity to total balance-sheet, a decomposition of all liabilities and the total balance sheet should form a cointegrating relationship. Hence, cointegration analysis can test whether banks target distinct liability ratios and whether they achieve this aim when facing fundamental ruptures in their funding conditions. My empirical approach reveals that cointegration can only be found after accounting for structural breaks. Identifying these structural breaks proves to be useful, as their estimates allow me to trace the channels that banks invoke to reallocate their balance sheets when hit by these major changes in funding conditions. The equity

[1]This chapter greatly benefited from fruitful discussions with Mathias Hoffmann. I am grateful for many ideas and comments.

to total balance sheet ratio features the inverse of the leverage ratio, meaning that my approach can trace the channels of leverage adjustments. To form hypotheses about the optimal adjustments of banks to ruptures in their funding conditions or risks in financial markets, I construct a tailored version of the workhorse banking model by Baltensperger and Milde (1987).

My empirical analysis exploits comprehensive balance-sheet data of four distinct German banking groups: large commercial banks, small commercial banks, public sector banks and cooperative banks. The estimation sample draws on all globally operating banks headquartered in Germany. I organize these banks by banking group to bring out the heterogeneity in terms of business model, funding structure or ownership.
The Lehman collapse and the subsequent freeze of interbank markets suggests itself as a major permanent break in the funding conditions of banks. One particular German banking group, public sector banks, have experienced another major event which has shaped their funding structure and portfolio allocation. By a decision of the *European Commission*, public sector banks lost their guarantee schemes in July 2005 with a grandfathering arrangement for liabilities incurred between 2001-2005 but maturing no later than 2015 (Brunner et al., 2004). Both the Lehman collapse and the withdrawal of guarantees enter the long-run analysis as key breaks in the funding conditions of public sector banks.
To proxy exogenous financial market risks that trigger short-run deviations from long-run ratios, I resort to the return difference between Moody's "Baa-" and "AAA"-rated long-run corporate bonds, denoted as the risk-spread. My objective is to approach the default risk of borrowing agents and the aggregate uncertainty in financial markets. My short-run empirical analysis shows which liabilities adjust and restore the long-run equilibrium ratios as impulse response functions when facing a shock in the exogenous risk spread.

This paper proceeds in several steps. A brief review of the relevant literature follows this outline. Section 4.2.1 describes the bank balance-sheet setup and offers the liability decompositions into three core sets which form the backbone of my empirical analysis. Section 4.2.2 derives the long-run cointegrated relationships. Turning to the empirical part, Section 4.3.1 provides some stylized facts of the data and precedes the presentation of my results: Section 4.3.1 relates to the long run, Section 4.3.3 to the short run. Finally, Section 4.4 concludes.

## 4.1 Literature Review

My paper builds on two strands of economic literature. The first strand relates balance-sheet dynamics and key issues of the banking business such as liquidity, leverage and lending to exogenous shocks. In a narrow sense, it elaborates on the so-called *bank-lending channel* stating that characteristics of bank balance sheets shape their response to monetary policy decisions (see for instance Bernanke and Blinder, 1988). The idea that heterogeneity among banks governs the effectiveness of monetary policy as exogenous shocks has sparked a sizable literature. My review presents only a choice. In a seminal paper, Kashyap and Stein (2000) argue that monetary policy exercises a stronger impact on those banks with less liquid balance sheets. Kishan and Opiela (2000) add that smallest and least capitalized banks reveal as most responsive. Cetorelli and Goldberg (2008) broaden the scope. They find that international operations shield banks from domestic monetary policy as internal capital markets reinforce or weaken the propagation of shocks. With the global banking crisis of 2008 the focus has shifted. Now the literature explores how balance-sheet characteristics and key issues of the banking business shape the response to financial market shocks. Ivashina and Scharfstein (2010) find that after the Lehman collapse banks that had been more exposed to the short-run debt market and credit-line drawdowns reduced their lending more sharply than did their competitors. Puri et al. (2011) identify a significant reduction in the lending of those savings banks that were linked to head institutions with a high exposure to the US subprime market. The twofold role of foreign banks in the financial crisis is explored by Cetorelli and Goldberg (2012). They show that global banks transmit shocks by relating the parent banks' funding needs to the balance-sheet contraction of foreign affiliates. Giannetti and Laeven (2012) put forward that the collapse of the syndicated loan market is traceable to banks re-balancing their portfolio in favor of domestic rather than foreign lending.

The second strand of literature deals with the methodology applied in this paper. To distinguish long-run and short-run perspective, I refer to the consumption-wealth literature. By interpreting a balance-sheet as a budget constraint in present value form, I motivate the link between balance-sheet constraints and cointegration analysis. Campbell and Mankiw (1989) lay the cornerstone for this type of model and Lettau and Ludvigson (2001) link them to financial market developments. Hoffmann (2006) allows for trend breaks and splits the cointegrating relationship with all components into three relationships drawing on two variables.

As distinct from that, my empirical approach finds structural breaks in the long-run liability ratios. Cointegration analysis allows me interpret structural breaks in terms of balance-sheet reallocations. Thereby, I can identify the liability channels that banks invoke to adjust their leverage in response to shocks. Indeed, i Silvestre and Sansó (2006) provide the toolkit to test for cointegration given structural breaks in the cointegrating vector.

My paper greatly benefits from these presented tools and applies them to balance-sheet dynamics. To the best of my knowledge, this is the first paper to interpret structural breaks in cointegrating relationships as channels of leverage adjustment. My paper contributes twofold to the existing literature. First, I distinguish between short- and long-run balance-sheet dynamics to identify long-run equilibrium ratios, structural breaks and most responsive liabilities in the short run. Second, I use detailed balance-sheet data, to examine the reallocation among liabilities and thus the liability channels to adjust leverage.

## 4.2 Deriving the Empirical Approach

### 4.2.1 Decomposing Leverage

This section deals with changes in leverage and more general liability decompositions of bank balance sheets. Figure C.1 sketches a stylized balance sheet with mutually exclusive items in bold print. Its liability side broadly imitates an official form ("HV12" shown in Appendix C.2) that the Bundesbank makes available for banks to report supervisory data. Let capital letters denote balance-sheet items as indicated by banks in levels and denominated in euro. The balance-sheet identity states that sources of *internal* and *external* finance sum up to the balance sheet total ($TBS$). $EQUITY$ corresponds to subscribed capital as a source of internal finance. The following items characterize sources of external finance ($EFIN$): $BONDS$ capture issued securitized debt, $DEBT$ features non-securitized debt, such as deposits and borrowed funds while $OTHER\ LIABILITIES$ serve as a residual catchall item. To shed light on the (de)leveraging process, my empirical analysis draws on three distinct decompositions of the liability side: set I, the baseline decomposes the total balance sheet into *EQUITY, BONDS, DEBT* and *OTHER LIABILITIES*. Set II adds a distinction between *foreign* and *domestic debt*, while set III separates *bank* from *non-bank debt*.[2]

According to the balance-sheet identity, *EQUITY*, *BONDS*, *DEBT* and *OTHER LIABILITIES* add up to the total balance sheet (*TBS* hereafter). Thus, leverage can be expressed by liability components as:

$$Leverage = {}^{TBS}/_{(EQUITY)} = {}^{TBS}/_{TBS-EFIN} = {}^{TBS}/_{(TBS-DEBT-BONDS-OTHERLIABILITIES)} \tag{4.1}$$

Hence, changes in leverage may ensue from non-offsetting changes in the components of sets I to III.

### 4.2.2 Econometric Traces of Changes in Leverage

The aim of this section is to derive possibly cointegrating relationships between various liability decompositions and the total balance sheet. My approach bears analogy to Campbell and Mankiw (1989); Lettau and Ludvigson (2004) and Hoffmann (2005). To build the bridge, one might interpret the balance-sheet identity as a budget constraint in present value form. Be it for regulatory reasons, be it for the purpose of profit maximization, the following chain of arguments strongly draws on the idea that banks exhibit a constant *equity to total balance sheet* ratio, the inverse of the *leverage* ratio.
To simplify, I split the total balance sheet $TBS_t$ only into equity $EQUITY_t$ and external finance $EFIN_t$ as a composite of other liability items [3] to arrive at the following version of the balance-sheet identity:

$$TBS_t = EQUITY_t + EFIN_t \tag{4.2}$$

Based on the assumption that banks exhibit a constant long-run *equity to total balance sheet* ratio, it is possible to approximate these long-run ratios. For this purpose, I take a first-order Taylor expansion[4] of the balance sheet-identity around the *equity to total* ratio

[2] Table C.1 gives the ultimate specifications in terms of potentially cointegrating relationships.

[3] This approach ignores any regulatory restrictions, as no risk-weights are involved when referring to the total balance sheet. For this reason, my paper restricts leveraging and deleveraging only to the total balance sheet and the liability decomposition while abstracting from the structure of the asset side.

[4] A step-by-step log-linearization of the *equity* ratio is provided in Appendix C.1.

expressed in logarithms ($equity_t - tbs_t$) and around the *external finance to total* ratio ($efin_t - tbs_t$). Letting lower case letters denote logarithms, Equation (4.3) suggests an equilibrium long-run relationship between equity, external finance and the total balance sheet $tbs$:

$$tbs_t = c_6 + \gamma equity_t + (1 - \gamma)\, efin_t \tag{4.3}$$

$\gamma$ denotes the long-run equilibrium share of equity to total balance sheet, whereas $(1 - \gamma)$ gives the long-run share of external finance to the total balance sheet. If banks exhibit constant equilibrium ratios, cointegration analysis serves as appropriate tool to examine Equation (4.4) with $\varepsilon_t$ as random deviation from the long-run ratios in period $t$:

$$tbs_t = c_6 + \gamma equity_t + (1 - \gamma)\, efin_t + \varepsilon_t \tag{4.4}$$

Table C.1 broadens the scope again. It lists the corresponding equations while splitting up debt into sub-components in line with Figure C.1 and the previously formed sets. By analogy, $\delta_2^I$ denotes the long-run equilibrium share of bonds in the total balance sheet, equivalently expressed as long-run *bond to total balance sheet* ratio.

In short, if banks exhibit constant ratios, liability decomposition sets should be cointegrated. In what follows, I will reverse this argument. Cointegration analysis provides the tools to test whether banks do indeed exhibit constant ratios such as the *equity to total* ratio. Put differently, finding cointegration among liability sets I to III would yield strong evidence that banks target constant *leverage* ratios, the flip side of the *equity to total.* However, in view of financial market turmoil and the subsequent banking crisis in September 2008, the question arises whether banks were actually able to target constant liability ratios.

As IMF (2011) puts forward, the Lehman collapse in September 2008 has left persistent traces in the liability decomposition of banks. Indeed, structural breaks in the cointegration term might stand for ruptures in long-run liability shares which invites me to interpret them as structural breaks in leverage or its decomposition.

In this vein, changes in *leverage* are not restricted to explicit movements in either *equity* or the total balance sheet *tbs.* The definition of leverage by Equation (4.1) suggests that sudden changes in leverage might run through different channels represented by different liability reallocations. Sets I to III reflect these channels. Applying cointegration tests in the presence of possible structural breaks to sets I to III can shed light on the channels that banks use to adjust their leverage. My empirical approach exploits comprehensive balance-sheet data to examine how banks re-organize their liability decomposition to tune their leverage. Having found cointegrating relationships with structural breaks, I can apply the tools of cointegration analysis. Vector error correction models and impulse response functions can shed light on how distinct balance-sheet items restore the equilibrium.

## 4.3 Empirical Evidence

### 4.3.1 Datasets and Sample Construction

Two datasets collected by the *Deutsche Bundesbank* set the stage for my empirical analysis. Both datasets consist of individual mandatory reports submitted by all banks with a German banking license. First, the "Monthly Balance Sheet Statistics" ("Monatliche Bilanzstatistik") dataset features comprehensive data on all balance-sheet items of German banks.[5] Second, the "External Position Report" ("Auslandsstatus") as described by Fiorentino et al. (2010) offers the corresponding data by country of foreign business. Both datasets are rich in coverage and detail. After combining the External Position Report with the Monthly Balance Sheet Statistics, I am able to use information on various classes of assets and liabilities and to distinguish between securitized and non-securitized items by maturities and even counterparty. To study leverage dynamics in light of banking groups' distinct characteristics, I construct aggregates for each of four individual banking groups. Thereby, I aim to bring out the heterogeneity in terms of business model, funding structure and ownership. Put differently, my empirical analysis draws on individual time series estimations by *banking group.* [6]

The dataset of my empirical analysis is constructed as follows. Starting from bank-level data, I restrict the sample to banks headquartered in Germany which, however, run foreign affiliates. My intention is to capture globally exposed banks with foreign commercial presence. In a second step I keep only those banks with a consecutive data

[5] Appendix C.3 gives further details, Figure C.2 shows an official reporting form.

[6] Besides, for reasons of confidentiality, the Bundesbank does not allow to report results from individual time series estimations by bank.

record from January 2002 to April 2010 to avoid discrete jumps. Hence, banks entering or exiting the German banking market drop out of the sample. In a third step, I aggregate the data by banking group.

Substantial heterogeneity characterizes the population of German banks: institutional setup, stake- or shareholders and the business model vary across banking groups. Banking group 1 includes large commercial banks and has 3 members. Banking group 2 includes small commercial banks and captures consecutive time series of 32 individual banks. Banking group 3 includes public sector banks as a composite group of (large) savings banks and their head institutions with 13 members in total. Finally, banking group 4 includes large cooperative banks and their head institutions, amounting to 10 member banks in total. An observational unit in the empirical analysis could be characterized as a representative synthetic composite bank: a large commercial bank, a small commercial bank, a public sector bank or a cooperative bank .

Figure C.3 depicts the size of the included banks aggregated by banking group relative to the sample at hand. As previously mentioned, I restrict the used dataset to complete records which causes public sector banks to appear as the largest banking group in terms of total balance sheet. Yet, Figure C.3 clearly shows that their share declines in the wake of the Lehman failure, whereas the share of large commercial banks increases.

Figure C.4 gives an impression of how much my analysis captures relative to the entire German bank population. On the left vertical axis, I plot the total balance sheet. The blue line represents the entire German bank population, whereas the red line represents my sample of internationally operating banks with permanent record. Turning to the share captured, the green line refers to the vertical axis to the right presenting the share of my sample aggregate relative to the aggregate of the entire population. Hence, my sample captures between 30% in 2002 and more than 40% in 2010. Its growth ensues unintentionally from the data.

Table C.2 presents some descriptive statistics. It relies on aggregated data across all banking groups in levels and EUR billions. The underlying monthly sample ranges from January 2002 to April 2010. Descriptive figures state that the domestic share in debt exceeds by far the foreign share (set II), whereas the foreign share exhibits less volatility. Bank debt outstrips non-bank debt (set III). Further, Table C.2 gives descriptive statistics of the risk-spread which enters the short-run analysis as weakly exogenous variable.

### 4.3.2 Long-Run Equilibrium Ratios and Structural Breaks

My paper examines leverage and the liability structure of balance sheets from a short and long-run perspective. This section focuses on the long-run. If liability shares are constant over time, liability decomposition sets as presented in Table C.1 will be cointegrated. Major changes in the funding conditions of banks, however, cast constant liability ratios into doubt. In econometric terms, I interpret major changes in these funding conditions as structural breaks.This section considers financial market turmoil in September 2008 for all banking groups and the withdrawal of guarantees in July 2005 for public sector banks as possible structural breaks. For this reason, cointegration analysis can test whether banks target constant ratios and whether they were able to do so when facing major changes in their funding conditions.

The next section develops hypotheses about the impact of structural breaks. Then, I briefly review the econometric tools to test for constant ratios and cointegration in the presence of structural breaks. My empirical results follow while tracing the leveraging and deleveraging of banks and the changes in their liability structure.

**Hypotheses about Structural Breaks**

To form hypotheses about how changes in funding conditions impact liability ratios, I build on a workhorse banking model of Baltensperger and Milde (1987). Appendix C.2 tailors the model of Baltensperger and Milde (1987) to my empirical setup. Baltensperger and Milde (1987) argue that banks simultaneously optimize the asset and liability structure of balance-sheets to maximize profits in competitive markets. The tradeoff between less profitable cash holdings and interest-bearing assets shapes (i) the *illiquidity risk*. By analogy, the tradeoff between deposit and equity finance shapes (ii) *insolvency risk*. In this sense, banks form expectations about their liquidity needs and their aggregate return to manage their illiquidity and insolvency risks. Objective costs arise to deal with both risks. Indeed, illiquidity and insolvency risks ensue from how participants perceive and think about risks on financial markets.

Figure C.5 motivates the inclusion of structural breaks into my analysis. It displays the *bank debt to total balance sheet* ratio for cooperative banks while marking the outset of the financial crisis in September 2008. I will interpret the Lehman failure in September 2008 as a permanent shift in parameters of the Baltensperger model. One might think about the interbank market freeze as a surge in restructuring costs $\eta$ or a surge in the penalty rate $p$ on interbank markets. With respect to a bank's customers, the Lehman default might trigger a shift in the volatility of liquidity needs $\Delta\sigma^v$ and/or a shock to the volatility of aggregate return $\Delta\sigma^r$. The optimal elasticities (C.24) and (C.25) recommend a reduction of external finance. For this reason, I hypothesize that banks substitute external finance for equity in the wake of the Lehman failure.

With respect to public sector banks, I present a regulatory change as a possible second structural break: In July 2005 the public owners' *maintenance obligation* ("Anstaltslast") and *guarantee obligation* ("Gewährträgerhaftung") underwent major change (see for instance Brunner et al., 2004; IMF, 2011). The *guarantee obligation* was transformed and will cease to exist after a transition period in December 2015. Until then, the so-called g*randfathering clause* states that liabilities which a public sector bank had incurred between July 2001 and July 2005 will be guaranteed, or "grandfathered", if they mature no later than December 2015.[7] Liabilities incurred after July 2005 are not subject to an explicit public guarantee. Hence, this date marks a crucial change in the funding conditions of public sector banks. Figure C.5 motivates the inclusion of two structural breaks for public sector banks. It displays the *bank debt to total balance sheet* ratio for public sector banks while marking both the withdrawal of guarantees in July 2005 and the outset of the financial crisis in September 2008. In light of Baltensperger and Milde (1987), I interpret the removal of guarantees as a surge in the costs of external finance $t$ for public sector banks. According to the optimal elasticities in C.22, I again hypothesize that they will substitute external finance for equity.

### Econometric Tools

My analysis applies time-series techniques separately to each individual banking group. To test for constant liability ratios, I follow standard procedures to test for cointegration. It starts with unit root tests of all individual time series and then proceeds to cointegration tests of entire liability sets per banking group. Ambivalent results on the cointegration

[7] Liabilities incurred before July 2001 will be captured until final maturity.

tests point out that banks do not exhibit constant liability ratios over the entire sample period. Hence, finding no cointegration leads me to test for structural breaks in the cointegrating relationships. This long-run consideration finishes with dynamic ordinary least squares (DOLS) estimation of the long-run equilibrium ratios in the presence of structural breaks. I interpret structural breaks as evidence of changes in liability ratios induced by major ruptures in the funding conditions of banks.

**Unit Root Tests** To verify that all balance-sheet items in the liability sets of Table C.1 have a unit root, I resort to *Augmented Dickey Fuller* (*ADF* ) tests as well as *Kwiatkowski Phillips Schmidt Shin (KPSS)* tests. To give way to the cointegration analysis below, all variables in levels should be integrated of order one I(1). Lütkepohl and Krätzig (2004) partly extend the definition of cointegration and allow for I(1) and I(0) variables to form a cointegrating relationship as long as a linear combination thereof is I(0). Consequently, even if it turns out that some liability items do not fulfill the I(1) requirement, this should not harm the appropriateness of further cointegration and VECM analysis.

For each banking group and balance-sheet item I run the *ADF* test on levels and first differences as developed by Dickey and Fuller (1979) and MacKinnon (2010). Figure C.7 plots the *ADF* test statistic of first differences against the test statistics of the times series in levels. The existence of three outliers related to small commercial banks and cooperative banks still allows to continue with cointegration and VECM analysis.

As opposed to the *ADF* test, the null hypothesis of the *KPSS* test as suggested by Kwiatkowski et al. (1992) states that a variable is stationary. Figure C.8 plots the *KPSS* test statistic of the variable in first differences against the *KPSS* test statistic of the variable in levels. Again, the extended definition of cointegration by Lütkepohl and Krätzig (2004) mitigates concerns about outliers.

**Standard Cointegration Analysis** Cointegration analysis seeks to absorb long-run phenomena into a cointegration vector. Recall that if both long-run liability ratios and leverage are constant, liability sets should be cointegrated. Thus, cointegration analysis can test whether banks target constant liability ratios and whether they are able to achieve this aim when facing severe ruptures in their funding conditions. Table C.3 features three different cointegration tests which are in turn applied to all sets for each banking group: the *Engle-Granger* (*EG)* test, the *KPSS* test and *Johansen's trace statistic.*

Engle and Granger (1987) suggest this residual-based test featuring a null hypothesis of non-cointegration, while critical values draw on MacKinnon (2010). The first panel of Table C.3 suggests that baseline set I is cointegrated only for large commercial banks. Set II involves a distinction between foreign and domestic debt and turns out to be cointegrated with respect to public sector and cooperative banks. Set III, while splitting debt into bank and non-bank debt, only forms a cointegrating relationship for large commercial banks. These mixed results gives rise to the inclusion of structural breaks.

Shin (1994) develops a residual-based test with a null hypothesis of cointegration based on the previously discussed *KPSS* test. As already stated, these findings strongly suggest the existence of structural breaks. The second panel of Table C.3 presents that cointegration is rejected for public sector banks in set II as well as small commercial banks in sets I and III. The Shin (1994) test and the Engle and Granger (1987) test come to the same conclusion, if the Shin test cannot reject its null of cointegration and the *EG* test rejects its null of non-cointegration. Inference based on some sets indeed point into the same direction, the overall evidence is, however, mixed.

*Johansen's trace statistic* Johansen (1995) relies on a likelihood ratio test with eigenvalues deriving from reduced regression techniques Lütkepohl and Krätzig (2004). For each banking group and liability set, the third panel of Table C.3 gives the number of cointegrating relationships. With respect to large commercial banks, results from the *Johansen* test align with the *KPSS* test but contrasts strongly with respect to cooperative banks. For this reason, I conclude that contradictory results provided by three different cointegration tests might ensue from possible structural breaks. From now on, the analysis focuses on cointegration analysis dealing with a single cointegrating relationship and potential structural breaks. This more closely suits the purpose of finding long-run cointegrating relationships in the liability decompositions.

**Structural breaks reflected by Dynamic OLS (DOLS) and Chow Tests** This study centers on whether banks exhibit constant liability ratios. If major changes in the funding conditions constitute structural break in cointegrating relationships, I can interpret these breaks as a change in the leverage ratios of banks. Previous results from conventional cointegration analysis did not provide clear-cut evidence on possibly cointegrated sets of liability decompositions. Yet, intuition suggests that liability decompositions as listed in Table C.1 share common stochastic trends. Structural breaks in the long-run relationships might solve the puzzle. i Silvestre and Sansó (2006) have advanced a cointegration test in the presence of structural breaks. Applied to my setup, their methodology serves several purposes. First, it yields explicit estimates of long-run ratios and interaction coefficients. Long-run ratios inform about differences in the liability structure across banking groups. Interaction coefficients indicate structural breaks and split up changes in leverage into distinct channels. Second, the *Chow* test informs about the overall significance of the structural break. Third, finding evidence of cointegration after accounting for structural breaks allows me to analyze short-run dynamics by means of VECMs and impulse response functions.

**The Carrion Test** Gregory and Hansen (1996a,b) develop a cointegration test which allows for breaks in the intercept, the deterministic trend and coefficient estimates. Their idea is to introduce the transition of a cointegrating equilibrium from one path to another. Yet, Gregory and Hansen do not account for the endogeneity of the regressors. i Silvestre and Sansó (2006) tackle this issue and extend their model to a multivariate framework. Their suggested test statistic involves regression residuals from a first stage *DOLS* estimation in which all coefficients are interacted with a break dummy. Equation (4.5) projects their idea on the simplified liability decompositions. It expands Equation (4.4) by leads and lags of first differences, a structural break dummy $B$ and the interaction terms:

$$\begin{aligned} tbs_t &= c + \gamma_0 equity_t + (1-\gamma_0)\, efin_t + B + \gamma_1 equity_t * B + \gamma_2 efin_t * B \\ &\quad + \sum_{k=-1}^{1} \delta_k \Delta equity_{t+k} + \sum_{k=-1}^{1} \tau_k \Delta efin_t + \varsigma_t \end{aligned} \tag{4.5}$$

Similar in spirit to Gregory and Hansen (1996a,b) the null hypothesis of i Silvestre and Sansó (2006) states cointegration while explicitly allowing for the possibility of a structural break in coefficient parameters. The consistent estimate of $\hat{\gamma}_0$ characterizes the long-run equilibrium *equity to total* ratio over the entire period. The coefficient estimate of the interaction term, $\hat{\gamma}_1$ states to which extent the regime shift has modified the *equity to total* ratio. Hence, structural breaks in the cointegrating relationship can be interpreted as changes in the liability ratios. A further split of the liability components allows me to trace the channels of deleveraging more explicitly.

**Structural Breaks** My analysis considers two structural breaks: the Lehman Collapse as well as the termination of guarantees for public sector banks, the so-called *grandfathering* clause. Results in Tables C.4 to C.6 inform about the long-run ratios over the entire sample period from January 2002 to April 2010 and further state in how far structural breaks have left persistent traces on balance sheets. To illustrate the tables' setup by help of the Lehman collapse and Equation (4.5), a structural break $B$ is modeled twofold: (i) a dummy variable labeled *lehman* assumes the value 0 and switches to 1 from September 2008 onwards, (ii) this dummy variable is interacted with all liability items of the respective set and carries the prefix $iL\_*$ throughout all tables. With respect to public sector banks I introduce the removal of public guarantees in July 2005 as a second structural break. The respective interaction terms carries the prefix $iG\_*$. These interaction terms $iL\_*$ and $iG_*$indicate which long-run liability ratios change in response to structural breaks. They identify the channels of leveraging and deleveraging given major changes in the funding conditions of banks. Dynamic OLS (DOLS) estimation allows to apply standard t- and F-tests of the coefficient estimates (Murray, 2006). For this reason, I use a *Chow* test to draw conclusions about the joint significance of all estimates related to the structural break, namely the dummy variable as well as the interaction terms.

### Results on Long-Run Ratios and Structural Breaks

Tables C.4 to C.6 present the results by banking group while distinguishing among the baseline model (set I), the split into *domestic* and *foreign debt* (set II) and the split into *bank* versus *non-bank debt* (set III). Columns two to five of all tables focus on the Lehman collapse as structural break separated by banking group. Columns six and seven solely feature public sector banks, with column six capturing the abolition of guarantees in isolation (*grandfa*) and column seven jointly considering both structural breaks. To test for cointegration in the presence of a structural break, *carrion* gives the test statistic of the *Carrion* test. The *Chow* test indicates whether banks significantly reallocated their balance-sheet in response to structural breaks.

**Large Commercial Banks (bg1)** As evidenced by the *Carrion* test in the second column of Table C.4, the null hypothesis of cointegration cannot be rejected at the 5% level of significance. Further, throughout all specifications in Tables C.4 to C.6 p-values of the *Chow* test tell about the joint significance of the Lehman interaction and dummy variables. These results propose that a structural break shapes the liability structure of large commercial banks.

Large commercial banks hold on average 76.5% of their liabilities as non-securitized debt and 10.2% as bonds. Equity amounts to about 5% and other liabilities make up almost 9% of the total.[8] In the wake of the Lehman collapse, large commercial banks have cut back on debt (-2.3%) and bond finance (-1.7%) but exhibit no significant effect on equity. These stylized facts broadly align with the Baltensperger model and hint at a significant deleveraging of large commercial banks.

A breakdown of debt into foreign and domestic debt (set II, Table C.5) and bank versus non-bank debt (set III, Table C.6) disclosed the channels of deleveraging more precisely. Estimates of the interaction coefficients in set II suggest that the overall reduction in debt ensues as a net effect. Indeed, an increase in domestic debt (3.3%) partly reverses a very pronounced drop in foreign debt (-7.1%) and bond finance. Generally, large commercial banks almost equally split their debt finance between domestic and foreign funding sources. Set III hints at a significant reduction of -2.9% in borrowing from other banks. Prior to the Lehman failure, large commercial banks relied more on bank debt (42.5%) than non-bank debt (34.4%). These findings allude to the prominent exposure of large commercial banks to international bank markets. To conclude, the deleveraging of large commercial banks mainly runs through a reduction in foreign debt, bank debt and issued bonds.

**Small Commercial Banks (bg2)** Results on the *Chow* test stress that the Lehman collapse has left persistent traces in the liability structure of small commercial banks throughout all sets (Tables C.4 to C.6). According to the *Carrion* test in the third column of Table C.4, cointegration given the structural break cannot even be rejected at the 10% level of significance. Small commercial banks exhibit an average funding pattern which is similar that to large commercial banks. Total liabilities can be decomposed into on average 73.5% debt, 10.5% bond, 6% equity finance and 10% of other liabilities. Yet, in comparison to large commercial banks, the adjustment in the wake of the Lehman collapse

[8]The share of average debt, equity and bond finance does not differ between set I and set II. Minor deviations in set II ensue from the consolidation of foreign branches and subsidiaries with their parent bank.

runs in the opposite direction: small commercial banks have raised their overall debt by almost 5.5% and reduced bond finance by -1.6%. Effects on equity and other liabilities turn out to be insignificant. These results allude to a leveraging-up in response to financial market turmoil. In fact, these measures are at odds with the optimal suggestions of the Baltensperger model.

A glance at set II (Table C.5) while decomposing debt suggests that restructuring operates through an almost equal increase in foreign (plus 4%) and domestic debt (4.9%). Set II hints at the crucial role of domestic against foreign funding: 63.7% of the total is domestic debt and foreign debt is about 11% on average. However, in view of discrepancies due to the consolidation of parent banks with foreign affiliates, these estimates might be questioned. Similar doubts related to set II emerge when considering that equity seems to have increased by 4% in the wake of the Lehman failure.

Set III (Table C.6) can avoid these concerns about consolidation. During the pre-Lehman period, small commercial banks relied more on non-bank funding (51.4%) than on tabbing the interbank market (21.6%). This finding might explain why evidence on set III does not hint at a significant deleveraging or leveraging after the Lehman collapse. To sum up, limited evidence on leveraging in the wake of the Lehman failure probably ensues from its limited exposure to international interbank markets.

**Public Sector Banks: Savings Banks and their head institutions (bg3)** With respect to public sector banks, my analysis considers two potential structural breaks. Besides the Lehman collapse, the abolition of public guarantees in July 2005 (the grandfathering effect) suggests itself as another structural break in the funding structure. The fourth column of Table C.4 captures the Lehman effect in isolation, the six column only relies on the grandfathering effect, whereas the last column captures both effects simultaneously. In terms of the Baltensperger model, one might interpret the grandfathering clause as a surge in the cost of external finance such as bonds or different types of debt. Optimal elasticity (C.22) suggests an decline in external finance in response to higher costs.

Cointegration in the presence of the Lehman structural break (iL_* related to *lehman*) cannot be rejected at the 10% level of significance. Results from the *Chow* test suggest that public sector banks have significantly restructured their balance sheet in the wake of the Lehman collapse. Turning to the structural break of the grandfathering effect (iG_* related to *grandfa*), cointegration cannot either be rejected at the 10% with the *Chow* test confirming the necessity to include this structural break. These findings lead to three conclusions: First, cointegration is a common phenomenon with respect to the liability structure when considering each break in isolation. Due to the fact that a linear combination of cointegrated relationships must be cointegrated as well Lütkepohl and Krätzig (2004), the short-run analysis draws on VECMs and thus runs in parallel to the other banking groups. Second, the significance of isolated events as well as their joint significance hints at the importance to rely on both events in the following analysis. Third, differences in the estimated long-run shares of column four, five and seven undoubtedly require the joint consideration of both breaks as an isolated view only yields biased long-run estimates.

Set I (last column in Table C.4) depicts a 58.6% share of debt finance and 30.3% bond finance. A glance at the changing average equity share confirms that the grandfathering effect needs to be considered to avoid misleading conclusions. In this vein, public sector banks report an average equity share of 3.8% while other liabilities account for 7.4% on average. The grandfathering clause has triggered an increase (+2.7%) in debt, a remarkable reduction in equity finance of more than -3% and a small drop in bond finance (-1.2%). These findings suggest a considerable increase in leverage, albeit they do not align with the optimal suggestions of the Baltensperger model. In the wake of the Lehman failure, equity increases by more than 3.1% again, whereas bond finance falls by another -1.8%. The change in debt finance reveals to be insignificant. On the whole, public sector banks seem to deleverage in the post Lehman period which corresponds to the optimal suggestions of the Baltensperger model.

Digging deeper into the debt decomposition, set II (Table C.5) suggests that domestic debt accounts for 43.7% and foreign debt for only 16.8%. of all liabilities. It turns out that the overall debt increase after the removal of guarantees is driven by an increase in domestic debt (+1.9%), while foreign debt or bond finance seem to be unaffected. The decline in equity which is not matched by a significant identical increase in debt suggest a rise in leverage. Public sector banks significantly restructure their liabilities during the post Lehman period. Foreign debt (-3.4%) and other liabilities (-1.9%) drop significantly with, however, no effect on equity. In sum, set II suggests a weak raise in leverage after the abolition of guarantees but provides strong evidence of a deleveraging process running through foreign debt after the Lehman collapse.

Set III (Table C.6) discriminates between bank and non-bank debt. On average, public sector banks rely on almost 34% bank-debt finance, whereas a little more than 24.6% is reported as debt vis-à-vis non-banks. After the removal of guarantees, public sector banks to increase their share of bank debt by almost 2% and reduce equity by -2.7%. Similar to set II, these findings hint at a leveraging after the removal of guarantees. Once liquidity dried up on international interbank markets in the wake of the Lehman collapse, public sector banks substituted away from bank debt (-3.2%) and bond finance (-4.9%) without any change in equity. For this reason, results of set III suggest a significant leveraging-up in the pre- and a significant deleveraging in the post-Lehman era. The leveraging-up runs through the (domestic) interbank market and a reduction in equity, while the deleveraging runs particularly through a reduction in foreign and bank debt as well as a decline in bond finance.

To draw a conclusion, both events, the grandfathering effect and the Lehman failure, have remarkably impacted on the balance-sheet structure of public sector banks. A comparison of isolated and joint effects justifies my comprehensive setup and points out that a restricted focus on either one event would have lead to highly distorted results. Pubic sector banks have partly reversed several reallocations which had been induced by the grandfathering clause after the Lehman collapse. Evidence is strong on a leveraging after the removal of guarantees. Evidence on the deleveraging process in the post Lehman era hints at a considerable contraction of foreign debt, bank debt and bond finance. To admit, some of these changes and the retreat from foreign and interbank markets, are likely to be shaped by government support measures as described by Buch et al. (2011a).

**Cooperative Banks including their head institutions (bg4)** Overall, empirical tests put forward that the Lehman failure has impacted on the liability decomposition of cooperative banks: The *Chow* test hints at the significance of the Lehman collapse throughout all specifications. Further, cointegration in the presence of the Lehman break cannot be rejected at the 10% significance level.

The liability composition of cooperative banks is largely dominated by debt, accounting for more than 72% of the total balance sheet. As pointed out by Brunner et al. (2004), deposits from other cooperative banks or their head institutions might explain this huge figure. Bond finance with an average of 16%, equity finance (1.7% on average) and other liabilities play a minor role. After the Lehman collapse in September 2008, cooperative banks have significantly restructured their liabilities. Debt finance dropped by almost -4%, whereas bond finance has increased by almost 6% and other liabilities by more than 2%. In terms of leverage, the baseline set I thus hints at a substitution of debt for bond finance. The change in other liabilities is also significant, such that a clear statement about leverage escapes this framework. Set II reveals that more than 58.6% of the total balance sheet is domestic debt and only 15.2% is borrowed from abroad. In the wake of the Lehman collapse, foreign debt fell by -4.3%. This suggests that the substitution effect mainly runs from foreign debt to bond finance, with domestic debt almost remaining untouched. Set III (Table C.6) distinguishes between bank and non-bank debt. The share of average bank debt lies at 53%, whereas non-bank debt accounts for 19% of all liabilities. These figures suggest the highest level of funding by means of bank debt. Again, these loans might also be issued domestically among cooperative banks or between cooperative banks and their head institutions. Despite this side information, the reduction in debt can clearly be traced back to a reduction in bank debt.

In sum, the Lehman collapse has triggered a major reallocation in the balance sheet of cooperative banks. Bond finance has been substituted for interbank funding which is partly attributable to a reduction in foreign and bank debt. Cooperative banks' stance on leverage seems to be almost unaffected.

**Summary** To conclude on the long run, cointegration analysis finds constant long-run ratios only after structural breaks are taken into account. The estimates of interaction coefficients with structural breaks indicate which liability ratios change in response to ruptures in the funding conditions of banks. In this light, large commercial banks reduce their leverage after the Lehman collapse mainly running through a decline in foreign, bank and bond finance. Small commercial banks exhibit weak evidence of a slight increase in leverage running through foreign and domestic debt. Public sector banks increase their leverage after the withdrawal of guarantees, but reduce it in the wake of the Lehman collapse running through foreign bank and bond debt. Cooperative banks take a neutral stance on leverage when facing changes in the funding conditions in international banking markets.

### 4.3.3 Short-Run Dynamics

The aim of this paper is to analyze the adjustment patterns of bank liabilities from a short- and long-run perspective. Now, short-run responses to exogenous financial market developments take center stage. To build the bridge between bank liabilities, leverage and risks in financial markets, I resort to a workhorse banking model of Baltensperger and Milde (1987). To reflect how risks shape the short-run balance-sheet dynamics, I apply VECMs and impulse response functions (IRFs) as econometric tools.

**Hypothesis about how exogenous risk spread shaped the liability decomposition**

This section develops hypothesis about banks' optimal short-run reactions to changes in financial market risks. It borrows again from Baltensperger and Milde (1987)[9] with banks simultaneously optimizing assets and liabilities to maximize profits in competitive markets. Two tradeoffs exist which shape the *illiquidity risk* and the *insolvency risk*. Again, banks form expectations and incur costs to manage their *illiquidity* and *insolvency* risks. Both risks are rooted in banks' perception and interpretation of financial market developments. To proxy financial market risk, I use the risk spread, defined as return difference between "Moodys Baa-" and "AAA"-rated long-run corporate bonds. Gatev and Strahan (2006) use the risk spread to proxy default risk. An increase in the risk spread requires a bank to be more sensitive towards heterogeneity among borrowing agents in the market. From a cross-sectional point of view, more and more pronounced variation in the customers' needs of funds arises. I interpret this either as more variation in bank revenues, or a bank's own *liquidity need* or a combination of both. Following Baltensperger and Milde (1987), both phenomena increase a bank's expected *liquidity* protection and/or *solvency* costs. Optimal measures to counter these developments and stay on the optimal path are proposed by the elasticities in Appendix Section C.2: the total balance sheet should contract according to optimal elasticities C.19 and C.20 while optimal structural

[9] Appendix section C.2 presents more details on the model.

elasticities C.24 and C.25 recommend that equity should replace external finance.

To translate Baltensperger and Milde (1987)'s optimal adjustments into leverage dynamics, I recall that Equation 4.1 defines leverage as the ratio of total balance sheet and equity. According to optimality conditions, an exogenous increase in risk spread triggers a balance-sheet contraction and a simultaneous rise in equity which ultimately results in a lower leverage ratio. My empirical analysis again features the three sets of liability decomposition (see Figure C.1) : set I, the baseline splits the total balance sheet (*TBS*, hereafter) into *Equity*, *Bonds*, *Debt* and *Other liabilities*. Set II adds a distinction between *foreign* and *domestic debt*, while set III separates *bank* from *non-bank debt.*

### Econometric Tools

Section 4.2.2 has pointed out that cointegration hinges on the assumption that liabilities exhibit constant long-run equilibrium ratios. However, with banks facing financial market turmoil and key ruptures in their funding conditions, Section 4.3.3 has shown that during the sample period from 2002 to 2010, cointegration only exists after taking structural breaks into account. To provide a proper view on the short-run adjustment mechanisms in ordinary times, this section abstracts from structural breaks and limits its view on large and small commercial banks a well as cooperative banks prior to the Lehman collapse in 2008. This procedure allows me to study how the risk-spread shapes short-run liability adjustments in ordinary times.

Based on *Granger's representation theorem* Engle and Granger (1987), Equation 4.6 gives a VECM which captures the joint dynamics of liabilities and the total balance sheet:

$$\Delta \mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}' \mathbf{x_{t-1}} + \mathbf{\Pi}\Delta \mathbf{x}_{t-1} + \boldsymbol{\varepsilon_t} \tag{4.6}$$

In line with the stylized version previously presented, the total balance sheet $tbs_t$ as well as all individual liability items ($equity_t$ and $efin_t$) enter the vector $\mathbf{x}_t$ as endogenous variables. Following Lütkepohl and Krätzig (2004), the risk spread enters Equation 4.6 as weakly exogenous variable to model its potential persistence. Thus, $\mathbf{x}_t$ denotes a $(K+1)\times 1$ vector with $K-1$ liability items $(1, ..., k, ..., K-1)$, the total balance sheet *tbs* and the risk spread. $\boldsymbol{\varepsilon_t}$ denotes the $(K+1)\times 1$ vector of disturbances. In case of $r$ cointegrating relationships, $\alpha$ and $\beta$ are parameter matrices of dimension $(K+1)\times r$, whereas $\Pi$ is a $(K+1)\times(K+1)$ matrix of parameters to estimate.

As captured by$\boldsymbol{\beta' x_{t-1}}$, I impose two cointegrating relationships on Equation 4.6 (i) the risk spread in isolation and (ii) the balance-sheet identity. The first cointegration term models the risk spread as weakly exogenous, persistent variable while muting all balance-sheet variables. The second cointegrating term picks up the DOLS estimates (Table C.6) of the long-run equilibrium relationship while muting the risk-spread. My intention to study short-run dynamics during the pre-Lehman period, justifies the omittance of the structural break and the reduced sample estimation.

In the presence of two cointegrating relationships ($r = 2$), matrix $\alpha$ can be decomposed into two vectors of size $(K+1)$ with the $\alpha_1$ relating to the risk-spread and $\alpha_2$ relating to the balance-sheet identity. Parameter element $\alpha_{11}$ captures the persistence of the risk spread, whereas elements $\alpha_{12}...\alpha_{1K}$ inform about the sensitivity of endogenous variables towards lagged values of the risk spread. Significant estimates of elements $\alpha_{22}$ to $\alpha_{2K}$ indicate whether these endogenous variables contribute to restore the long-run equilibrium ratios. Further, the size of $\alpha_{22}$ to $\alpha_{2K}$ tell about the speed of adjustment. Besides, parameter matrix $\Pi$ tells about the impact of lagged changes in the risk spread and balance-sheet variables. Estimates of elements $\Pi_{12}...\Pi_{1K}$ indicate whether lagged changes in the risk spread shape contemporary changes in balance-sheet variables.

Apart from the VECM, I apply IRFs to examine the balance sheet dynamics given a positive one unit standard deviation shock to the risk spread.

### Results on Short-Run Adjustments

Tables C.7 to C.9 present the VECM results for liability sets I to III based on the limited sample period from January 2002 to August 2008. The first panel of each table refers to large commercial banks , the second panel to small commercial banks and the third panel to cooperative banks .[10]

Each column in Tables C.7 to C.9 stands for the respective endogenous variable in first differences. [11] The risk spread enters the VECM as weakly exogenous variable. For expositional ease, I omit a separate risk-spread column. The cointegration terms are denoted as *coint_spread* to account for the persistence of the risk spread and *coint_identity*

[10] As pointed out by the cointegration analysis, the first structural break for public banks occurs in July 2005. This early break reduces the sample period too much to yield robust results in the short-run analysis.

[11] D denotes first differences, L denotes lags and LD denotes lagged first differences.

to account for the balance-sheet identity. Estimated coefficients of *coint_spread* inform about the sensitivity of the respective endogenous balance-sheet variable with respect to exogenous financial market risks proxied by lagged values of *spread risk*. Estimated coefficients on *coint_identity* indicate which balance-sheet items correct for past deviations from the long-run equilibrium.

Besides, two statistics reflect the fit of the model: First, the $R^2$ statistic gives the share of explained variation in each involved endogenous variable. Second, the p-value of a *Chi-square* test indicates whether all estimated coefficients in a particular endogenous equation jointly equal zero.

Figures C.9 to C.11 display impulse response functions induced by a one standard deviation shock in risk spread. They show bootstrapped median estimates and the associated 90% confidence bands based on the reduced sample period January 2002 to August 2008. To draw the parallel to the Baltensperger model, I reduce the impulse response analysis to liability set III featuring the split into *bank* and *non-bank debt*.

**Large Commercial Banks (bg1)** The upper panel of Table C.7 presents the baseline decomposition of the *total balance sheet* (*tbs*) into *debt*, *bonds equity* and *other liabilities*. It points out that the model with risk spread as *weakly exogenous* variable explains substantial shares in, for instance, *tbs* (33%) or *debt* (26.7%). According to the p-value of the *Chi-squared* test[12], coefficients are jointly significant at the 5% level in all equations except for *bonds*. The upper panels in Tables C.8 and C.9 confirm this overall fit while splitting debt into *foreign* and *domestic* as well as *bank* and *non-bank debt*. As to the error correction mechanism (*coint_identity*), it turns out that all balance-sheet items except for *bonds* contribute to restore the long-run equilibrium ratios. A closer look at the debt components suggests that *domestic debt*, *foreign debt* (Table C.8) and *bank debt* (Table C.9) correct for past deviations, whereas *non-bank debt* does not participate. The fact that *non-bank* debt contains mainly deposits, might explain this outcome.

To shed light on large commercial banks' sensitivity in view of financial market risks, I look at the VECM estimates as well as the impulse response functions. Tables C.7 to C.9 point out that the *total balance sheet* (*tbs*) and *equity* equation carry significant coefficients on *coint_spread* throughout all specifications, while *bank debt* does also exhibit

[12]Denoted as Pval(df, chi2).

some sensitivity in Table C.9.

Figure C.9 shows bootstrapped median estimates of endogenous variables' impulse responses given a one standard deviation shock in risk spread. It broadly mirrors the VECM estimates. Given an increase in risk spread, large commercial banks expand their balance sheets while increasing *bank debt*, *bonds*, *other liabilities* and *equity*. These balance-sheet dynamics lie at odds with the optimal suggestions of the Baltensperger model. In terms of leverage, a clear-cut statement is hard to derive. Effects from a simultaneous increase of the total balance sheet and equity might cancel and leave leverage unaltered.

**Small Commercial Banks (bg2)** The second panels in Tables C.7 to C.9 provide VECM results for liability sets I to III with respect to small commercial banks. According to the $R^2$ statistic in Table C.7, the model explains up to 35.9% of the variation in the total balance sheet and up to 30.6% of the variation in *debt*. Throughout all equations of set I, the *Chi-squared* test points at jointly significant coefficients. Tables C.8 and C.9 strongly support this overall fit.

Turning to the error-correction mechanism, small commercial banks exhibit similar patterns to large commercial banks. The significance of *coint_identity* hints at the fact that these endogenous variable contributes to restore the long-run equilibrium. Again, the *total balance sheet* (*tbs*), *debt* and *equity* mainly perform this task. The split in Tables C.8 and C.9 reveals that *foreign* and *bank debt* drive the result of *debt* as a contributor to mean reversion.

As to the sensitivity towards financial market risks, evidence from small commercial banks clearly contrasts with evidence from large commercial banks. Neither the *coint_spread* coefficient, nor lagged differences of the *risk spread* turn out to be significant in the baseline liability set I (Table C.7). This picture changes slightly when considering liability sets II and III. Table C.8 shows that *equity* might be affected by the *risk spread*, Table C.9 states that the *risk spread* triggers adjustment in *bank debt* and issued *bonds*. Figure C.10 presents the impulse responses of liability set III given a shock to the *risk spread*. In line with the results of Table C.9, small commercial banks substitute *bonds* for *bank debt* given a rise in the risk spread. These mechanisms again lie at odds with the optimal suggestions of the Baltensperger model. Further, the liability swap does not affect the leverage of small commercial banks. One reason for this behavior might be found in the locus business focus of small commercial banks.

**Cooperative Banks including their head institutions (bg4)** The lowest panels in Tables C.7 to C.9 give the VECM results for liability sets I to III with respect to cooperative banks and their head institutions. As indicated by the $R^2$ statistic, and the *Chi-squared* test, the model performs very well in case of some variables and rather poorer in case of others. For instance, up to 41.7% of the variation in *bonds* is explained by the model (see the $R^2$ in Table C.7), whereas all coefficients are hardly significant at the 10% level as to the *debt* equation. Remarkably, jointly insignificant coefficients in the *bank* and *non-bank* debt equation of set III (see Table C.9) state that the model fails to explain variation in *debt* and its components.

To restore the long-run equilibrium ratios, only *bonds* seem to correct for past deviations from equilibrium levels. Tables C.7 to C.9 show that this result is robust across liability decomposition sets.

In view of changes in financial market risks, *debt* (Table C.7) and the *total balance sheet* (Table C.8) exhibit significant coefficients on *coint_spread*. In particular, *foreign debt* and *bank debt* drive the result (see Table C.8 and C.9). Figure C.11 provides more details on the mechanism triggered by a positive shock to the *risk spread*. Cooperative banks reduce their *non-bank debt* and *bonds* while slightly increasing *equity*. The median impulse response function on the *total balance sheet* suggest a slight balance-sheet contraction. Overall, these mechanisms broadly suit the optimal adjustments of the Baltensperger model. The adjustment mechanism as a whole suggests a reduction of leverage when facing an increase in *risk spread*. A hint at the institutional background, the stakeholders and domestic retail business might explain these results.

**Summary** To sum up, the VECM models short-run variation in the liability structure of banks quite well. Large and small commercial banks differ considerably from cooperative banks with respect to the balance-sheet items which restore the long-run equilibrium ratios. In case of commercial banks, the total balance sheet, equity and debt, in particular foreign and bank debt, correct for past deviations. In the case of cooperative banks, bonds restore the long-run equilibrium ratios. Further, considerable heterogeneity governs the adjustment patterns of banking groups when facing a shock in financial market risks. Large commercial banks expand their balance sheet and raise *equity* which does not have clear-cut implications for their leverage ratio. Small commercial banks substitute *bonds* for *bank debt* and thus take a neutral stance on leverage. Solely cooperative banks broadly act in line with the Baltensperger model, while reducing their leverage.

## 4.4 Discussion and Conclusion

This study separates the long-run from a short-run dimension in the analysis of leverage and related liability ratios. If banks exhibit constant liability ratios, decomposed sets of liabilities form cointegrating relationships. Hence, cointegration analysis absorbs the long-run patterns and can test whether banks target certain liability ratios. My analysis demonstrates that liability sets are only cointegrating when taking structural breaks into account. I consider two possible structural break that might shape long-run ratios. The Lehman collapse and the subsequent freeze of the interbank market in September 2008 serve as one structural break. In the case of public sector banks, I incorporate the abolition of state guarantees in July 2005 as a second structural break. For the long run, this procedure allows me to trace the channels that banks invoke to adjust their long-run liability structure when facing key ruptures in their funding conditions. For the short run, my results point at those liabilities that adjust for past deviations from the long-run ratios as induced by changes in financial market risks. A tailored version of a banking model by Baltensperger and Milde (1987) allows me to form hypotheses about the optimal adjustment patterns to ruptures in banks' funding conditions or risks in financial markets.

My long-run approach finds that the Lehman failure has led to major reallocations in the liability structure and hence leverage of all banking groups. Large commercial banks cut their leverage after the Lehman collapse with the effect mainly operating through a decline in foreign, bank and bond finance. Small commercial banks provide weak evidence of a slight increase in leverage operating through foreign and domestic debt. Public sector banks increase their leverage after the termination of guarantees, but reduce it in the wake of the Lehman collapse operating through foreign, bank and bond debt. Cooperative banks take a neutral stance on leverage in view of changes in the funding conditions in international banking markets.

My short-run approach finds that considerable heterogeneity governs the adjustment patterns of banking groups given changes in financial market risks. Large commercial banks expand their balance sheets and raise equity which does not yield any clear-cut implications for their leverage ratio. Small commercial banks replace bonds for bank debt and thus take a neutral stance on leverage. Solely cooperative banks act broadly in line with the Baltensperger model, by reducing their leverage. As public sector banks experience two structural breaks, the first one as early as July 2005, the reduced estimation sample does not leave enough observations to conduct a short-run analysis. A more general consideration of the short-run suggests that VECMs reflect short-run variation in the liability structure quite well. Large and small commercial banks differ substantially from cooperative banks with respect to the balance-sheet items that restore the long-run equilibrium ratios. In case of commercial banks, the total balance sheet, equity and debt, in particular foreign and bank debt, correct for past deviations. In case of cooperative banks, bonds restore the long-run equilibrium ratios.

To conclude, a proper analysis of banks' liability structures requires to distinguish between a short- and a long-run dimension. Heterogeneity governs the adjustment of different banking groups when facing key ruptures in their funding conditions or changes in financial market risks.

These results yield valuable insights for policymakers. In the wake of the Lehman crisis some German banks enjoyed direct government support measures, others benefited from concerted actions (see Buch et al., 2011a). Recently, the ECB has provided huge amounts of liquidity by means of two long-run refinancing operations in December 2011 and February 2012. The aim was to keep banks afloat and secure the well functioning of the interbank market. Even if not all German banks are immediately affected, these initiatives have repercussions throughout the whole banking sector. For this reason it is of key importance to bear in mind that changes in the funding conditions have different impacts on different banking groups.

# Appendix C

# Risky Adjustments or Adjustments to Risks

## C.1 Log-Linearization

To derive the cointegration term in logs, I draw on set I of Table C.1 as an example which features the total balance sheet $tbs_t$, non-securitized liabilities $debt_t$, securitized liabilities $bond_t$, other liabilities $lother$ and equity $equity_t$. This procedure borrows from Lettau and Ludvigson (2001); Hoffmann (2006) who found their argument on the intertemporal budget-constraint of households instead of the balance-sheet identity used in this paper. As a starting point, I express these balance-sheet items in absolute terms as evidenced by capital letters. The balance-sheet identity states that non-securitized liabilities $DEBT_t$, securitized liabilities $BOND_t$, other liabilities $LOTHER_t$ and equity $EQUITY_t$ sum up to equal total liabilities and thus the total balance sheet. Hence $TBS_t = DEBT_t + BOND_t + LOTHER_t + EQUITY_t$. To simplify the derivation, I will reduce the focus on equity and external finance, with external finance capturing all the remaining liability items $EFIN_t = DEBT_t + BOND_t + LOTHER_t$.

This identity can also be rewritten as shares of total assets $1 = \frac{EFIN_t}{TBS_t} + \frac{EQUITY_t}{TBS_t}$ or $1 - \frac{EQUITY_t}{TBS_t} = \frac{EFIN_t}{TBS_t}$ . An equivalent transformation of exponentiating and taking logs yields $1 - e^{ln\frac{EQUITY_t}{TBS_t}} = e^{ln\frac{EFIN_t}{TBS_t}}$ and substituting log expressions by small letters gives $1 - e^{equity_t - tbs_t} = e^{efin_t - tbs_t}$. After again taking logs on both sides, I will consider both sides of Equation C.1 separately:

$$ln\left(1-e^{equity_t-tbs_t}\right)=ln\left(e^{efin_t-tbs_t}\right) \tag{C.1}$$

The left-hand side of expression C.1 is a non-linear function of the log equity to balance sheet total ratio $equity_t - tbs_t = x_t$. By analogy to the approach of Campbell and Mankiw (1989), I apply a first-order Taylor expansion of the function $ln\left(1-e^{x_t}\right)$ around $x_t=\bar{x}$. Put differently, I assume that banks target a fixed long-run equity ratio. The aim is to get an approximation of the long-run ratios of particular liability types to the total balance sheet based on the permanently valid balance-sheet identity. According to the Taylor approximation $y_t \backsimeq g(\overline{x})+g'(\overline{x})(x_t-\overline{x})$, I obtain the following expression for the left-hand side of C.1:

$$LHS_t=ln\left(1-e^{\overline{equity}-\overline{tbs}}\right)+\frac{e^{\overline{equity}-\overline{tbs}}}{1-e^{\overline{equity}-\overline{tbs}}}\left(equity_t-tbs_t-\left(\overline{equity}-\overline{tbs}\right)\right)$$

Rearranging terms and subsuming time-invariant expressions by constants $c_1=ln\left(1-e^{\overline{equity}-\overline{tbs}}\right)$ further $c_2=\frac{e^{\overline{equity}-\overline{tbs}}\left(\overline{equity}-\overline{tbs}\right)}{1-e^{\overline{equity}-\overline{tbs}}}$ and $c_3=c_1-c_2$results in:

$$LHS_t=c_3+\frac{e^{\overline{equity}-\overline{tbs}}}{1-e^{\overline{equity}-\overline{tbs}}}\left(equity_t-tbs_t\right).$$

The fraction $\frac{e^{\overline{equity}-\overline{tbs}}}{1-e^{\overline{equity}-\overline{tbs}}}$ can equivalently be expressed as $\frac{\frac{\overline{EQUITY}}{\overline{TBS}}}{1-\frac{\overline{EQUITY}}{\overline{TBS}}}=\frac{\overline{EQUITY}}{\overline{TBS}-\overline{EQUITY}}$ to obtain:

$$LHS_t=c_3+\frac{\overline{EQUITY}}{\overline{TBS}-\overline{EQUITY}}\left(equity_t-tbs_t\right) \tag{C.2}$$

Now, I turn to the right-hand side of Equation C.1, namely $ln\left(e^{efin_t-tbs_t}\right)$. Again, I apply a first-order Taylor expansion, this time of the function $ln\left(e^{x_t}\right)$ around $x_t=\bar{x}$. Now $\bar{x}$ denotes a constant debt to total balance sheet ratio .

$$RHS_t=ln\left(e^{\overline{efin}-\overline{tbs}}\right)+\frac{e^{\overline{efin}-\overline{tbs}}}{e^{\overline{efin}-\overline{tbs}}}\left(efin_t-tbs_t-\left(\overline{efin}-\overline{tbs}\right)\right)$$

The first term cancels with $\overline{efin}-\overline{tbs}$ in the second part such that I obtain:

$$RHS_t=efin_t-tbs_t \tag{C.3}$$

Combining left-hand side C.2 and right-hand side C.3 yields:

$$c_3 + \frac{\overline{EQUITY}}{\overline{TBS} - \overline{EQUITY}} \left(equity_t - tbs_t\right) = efin_t - tbs_t$$

which can be solved for $tbs_t$ as:

$$tbs_t \frac{-\overline{TBS}}{\overline{TBS} - \overline{EQUITY}} = c_3 - efin_t + \frac{\overline{EQUITY}}{\overline{TBS} - \overline{EQUITY}} equity_t$$
$$tbs_t = -c_3 \frac{\overline{TBS} - \overline{EQUITY}}{\overline{TBS}} + \frac{\overline{TBS} - \overline{EQUITY}}{\overline{TBS}} efin_t + \frac{\overline{EQUITY}}{\overline{TBS}} equity_t$$

which can be simplified by help of $c_6 = -c_3 \frac{\overline{TBS} - \overline{EQUITY}}{\overline{TBS}}$ and denoting long-run shares of equity to total balance sheet as $\gamma = \frac{\overline{EQUITY}}{\overline{TBS}}$ and long-run shares of external finance to total balance sheet as $1 - \gamma = \frac{\overline{TBS} - \overline{EQUITY}}{\overline{TBS}}$. Finally, I obtain the cointegration term:

$$tbs_t = c_6 + \gamma equity_t + (1 - \gamma)\, efin_t \tag{C.4}$$

Equation C.4 allows to analyze the local behavior of a non-linear expression by studying the linear approximation given by its derivative a the steady state De la Fuente (2000).

## C.2 Theoretical Model (Baltensperger Milde)

### Assumptions and Setup

This section develops hypothesis about banks' optimal responses to exogenous shocks. It attempts to tailor the ideas of Baltensperger and Milde (1987) to my empirical setup and suggests that banks simultaneously optimize the asset and liability structure of balance-sheets to maximize profits on competitive markets. Hence, banks take interest rates (on deposits and loans) as given and adjust their volume of loans and deposits, respectively. Further, Baltensperger and Milde (1987) abstract from reserve requirements and any temporal dimension. A coarse description of the balance sheet as in figure C.1 distinguishes between cash and interest bearing assets on the asset side and external finance [1] and

[1] External finance in this context captures deposits, bonds and debt as borrowed funds from other agents. The key intention is to contrast internal funds like equity with external funds. To be consistent with the underlying approach of Baltensperger and Milde (1987), I restrict the terminology to deposits

equity finance on the liability side. Banks form expectations about two types of random variables: (i) their *liquidity need* $v$ and (ii) their aggregate *return* $r$ on interest-bearing assets. These random variables introduce two types of risks to the model: (i) *illiquidity* risk which is related to the random liquidity need $v$ and (ii) *insolvency* risk associated with the random aggregate return $r$. To deal with both risks, objective costs arise. Banks can organize their balance-sheets such that they are more or less exposed to *illiquidity* and *insolvency* risks. In this respect, the tradeoff between less profitable cash holdings and interest-bearing assets shapes (i), the *illiquidity* risk. By analogy, the tradeoff between deposit and equity finance tunes the exposure to (ii) *insolvency* risks. At first, this section introduces the objective function of banks which features *solvency* and *liquidity* protection costs to cover a bank's expectations about its *liquidity need* $v$ and aggregate *return* $r$. Exogenous financial market variables shape the objective function but initially enter the model as fixed parameters. Based on this setup, first-order conditions allow me to develop hypothesis about a banks optimal balance-sheet reallocation in response to changes in these exogenous variables.

**Objective Function** A common objective function of banks describes expected profits as the difference between asset revenues and costs. As cash holdings $R$ do not carry any measurable interest, the asset revenue only features $\mu^r K$ as revenue on interest-bearing assets $K$ with $\mu^r$ denoting the expected aggregate return. Costs consist out of payments on deposits[2] $tD$ ($t$ as deposit rate and $D$ as deposit level) and equity $\rho W$ (with $\rho$ as cost rate of equity proxied by dividends and $W$ as equity level), operation costs $\Omega(K, D)$, liquidity protection costs $X(R, D)$ and solvency costs $Y(K, D)$. More details on various types of costs follow below. At this stage, it suffices to state that operation, liquidity and solvency costs depend on deposits $D$ and either the volume of interest-bearing assets $K$ or cash holdings $R$. Equation C.5 gives the profit function and budget constraint expressed

as external finance in this theoretical part. Conclusions about debt in form of borrowed funds, however, run in parallel.

[2]To simplify, I follow Baltensperger and Milde (1987) and use deposits as a proxy for any source of external finance (ie borrowing from other banks, issuing bonds) with an explicit interest rate. My intention is to contrast equity as internal with debt as external source of funding. This device does not harm any conclusions and suits the model of Baltensperger and Milde (1987)

in levels:

$$
\begin{aligned}
E[\pi] &= \mu^r K - tD - \Omega(K,D) - X(R,D) - Y(K,D) - \rho W && \text{(C.5)}\\
K + R &= D + W
\end{aligned}
$$

To remain consistent with Section 4.2.2, Equation C.6 restates the expected profit function in terms of total balance sheet $A$ and shares of balance-sheet items. Hence, the shares of interest-bearing assets ($\alpha = {}^{K}/_{A}$) and cash ($1-\alpha = {}^{R}/_{A}$) add up to one and so do the shares of deposits ($\beta = {}^{D}/_{A}$) and equity ($1-\beta = {}^{W}/_{A}$).

$$E[\pi] = [\alpha\mu^r - \beta t - (1-\beta)\rho] A - X(A,\alpha,\beta) - Y(A,\alpha,\beta) - \Omega(A,\alpha,\beta) \tag{C.6}$$

The term $[\alpha\mu^r - \beta t - (1-\beta)\rho]$ gives a weighted average of incoming revenues and paid cost rates. Benefits from cash holdings enter the function of liquidity costs $X(A,\alpha,\beta)$.

***Liquidity need*** $v$**, expected *liquidity* protection costs X and *illiquidity* risk** To service their depositors, banks themselves hold cash $R$. In this simplified setup, the exact amount of demanded deposit corresponds to the banks' unknown *liquidity need* $v$, a random variable. Yet, cash holdings $R$ are unprofitable. Holding more cash means having a higher buffer against unexpectedly high *liquidity needs*. This, however comes at the cost of forbearing profitable investment opportunities. The tradeoff between cash and asset holdings tunes the degree of *liquidity* risk a bank is running. If cash holdings exceed the *liquidity need* ($R > v$) a bank accepts forgoing interest on more profitable assets. If, however, cash holdings fall short of the *liquidity need* ($R < v$), the bank has to borrow the difference ($v - R$) from other agents at a penalty rate $p$. With $\gamma(v)$ as probability density function of the *liquidity need*, Equation C.7 describes the expected *liquidity* protection cost $X$.

$$X = p \int_R^{\infty} (v - R)\,\gamma(v)\,dv \tag{C.7}$$

As $X$ declines in the level of cash $X_R < 0$ (since $\frac{\partial X}{\partial R} = -p\int_R^{\infty}\gamma(v)\,dv$) but marginal liquidity cost increases in the level of cash $X_{RR} > 0$ (since $\frac{\partial^2 X}{(\partial R)^2} = p\gamma(v)$), the *liquidity* costs are a convex function of the cash level $R$. Further, liquidity protection costs increase with a higher penalty rate $p$, hence $X_p > 0$.

The aim of what follows is to link *liquidity* protection cost to deposits. Banks service many depositors which means that the *liquidity need* $v$ ensues from the deposit demand of many customers with different levels of deposits. To facilitate, let's assume that all $n$ existing deposit accounts are of equal size $\overline{D}$ (with$D = n\overline{D}$) but depositors' individual demands vary. A banks *liquidity need* can now be stated as sum of all individual deposit demands $v = \sum_{j=1}^{n} v_j \overline{D}$. When assuming a common individually expected value $E(v_j) = \mu^v$ and variance $Var(v_j) = a^2$ of uncorrelated deposit demands for $(j = 1...n)$, the variance of the *liquidity* need at the bank level becomes[3] $Var(v) = \overline{D}Da^2$. Hence, the variance (or standard deviation $\sigma^v = [Var(v)]^{1/2} = (\overline{D}D)^{1/2} a$) of a bank's liquidity need increases with its level of deposits ($\sigma^v_D > 0$). A standardization of *liquidity* need $v$ by help of its mean $\mu^v$ and standard deviation $\sigma^v$ explicitly alters the expression of the *liquidity* protection cost in C.7 and results in

$$X = p\sigma^v \int_{\hat{u}}^{\infty} (u - \hat{u})\, g(u)\, du \tag{C.8}$$

with $\hat{u} \equiv \frac{R}{\sigma^v}$ and $u \equiv \frac{v}{\sigma^v}$. Equation C.8 points out that liquidity protection costs $X$ increase in the deposit level ($X_D > 0$) and decline in the level of cash holdings ($X_R < 0$). A final restatement in terms of total balance sheet and shares puts forward that liquidity protection cost $X(A, \alpha, \beta)$ positively depend on the share of interest-bearing assets $X_\alpha = X_R(-A) > 0$, the share of deposits $X_\beta = X_D A > 0$ and total balance sheet $X_A = X_D \beta > 0$. The underlying reasoning is that a lower share of interest-bearing assets relative to cash holdings $\alpha$ can absorb more deposit demands and thus reduces the risk as well as the costs of illiquidity. On the liability side, a higher level of deposits relative to equity ($\beta$) raises the variance of random liquidity needs and thereby raises the expected costs of liquidity protection $X$. As distinct from the total balance sheet, $\alpha$ and $\beta$ denote the structural parameters of the model.

**Aggregate *return* $r$, expected *solvency* costs Y and *insolvency* risk** If a bank's total liabilities exceed the market value of its total assets, the bank becomes insolvent. This might happen if the aggregate *return* $r$ on interest-bearing assets, the second random

[3] as $Var(v) = \overline{D}^2 Var \sum_{j=1}^{n}(v_j) = \overline{D}^2 na^2 = \overline{D}Da^2$

variable in this setup, falls below a certain threshold value $\hat{r}$ which characterizes the equality of total assets and liabilities. In the previous paragraph, cash holdings serve as a buffer against uncertain *liquidity* needs which ensue from a multitude of unknown individual deposit demands on the liability side. To draw the analogy, equity serves as a buffer against uncertainty about the aggregate *return* $r$ which subsumes loan defaults or other losses on the asset side of the balance sheet. Once the aggregate return falls below $\hat{r}$, a bank is threatened by insolvency if it does not take immediate action. It has to undergo costly restructuring, be it in terms of organization, liquidation or be it in terms of portfolio reallocation to avoid insolvency. These costs a bank has to incur in order to remain solvent are termed *solvency* costs. Equation C.9 models the expected solvency costs $Y$ as function of interest-bearing assets $K$ and a proportional cost rate $\eta$ while $b\,(r)$stands for the probability density function:

$$Y = \eta K \int_{-\infty}^{\hat{r}} (\hat{r} - r)\, b\,(r)\, dr \tag{C.9}$$

By analogy to the *liquidity need*, the aggregate *return* $r$ can be decomposed into individual returns $r_i$ on $m$ individual interest-bearing assets $K_i$ meaning that $r = \sum_{i=1}^{m} r_i \frac{K_i}{K}$. Using constant sizes, that is $K_j = \overline{K}$ (or $K = m\overline{K}$), the aggregate return can be restated as $r = \frac{1}{m}\sum_{i=1}^{m} r_i$. Further, when assuming a common individually expected value $E\,(r_i) = h$ , common variance $Var\,(r_i) = c^2$ and independent outcomes ($Corr(r_i, r_g) = 0$) for all $i = 1, ..., m$, the variance of aggregate return at the bank level is given by[4] $Var\,(r) = \frac{c^2}{m}$. Recalling that $m = \frac{K}{(\overline{K})}$ and keeping $\overline{K}$ constant, the variance (or standard deviation $\sigma^r = [Var\,(r)]^{1/2} = cm^{-1/2}$) of the aggregate return declines in the number of assets $m$ and even in the aggregate level $K$. This decline in variance alludes to a diversification effect which strongly relies on the assumption of stochastically independent outcomes. More telling, however, is the variance of aggregate interest-bearing asset volume $rK$ which increases in the volume of K as $Var\,[rk] = {c^2K^2}/{m} = K\overline{K}c^2$.

To gain insights about the link between $Y$ and the deposit level $D$, a standardization of the aggregate *return* $r$ by help of its expected value $\mu^r$ and standard deviation $\sigma^r$,

[4]as $Var\,(r) = \frac{1}{m^2} Var \sum_{j=1}^{n} (r_i) = \frac{1}{m^2} \sum_{j=1}^{n} Var\,(r_i) = \frac{c^2}{m}$

suggests the expected *solvency* cost Equation C.10:

$$Y = \eta K \sigma^{r} \int_{-\infty}^{\hat{\tau}} (\hat{\tau} - \tau)\, h(\tau)\, d\tau \tag{C.10}$$

Now $\hat{\tau}$ $(\equiv \frac{\widehat{r}-\mu^r}{\sigma^r})$ captures the threshold return level $\widehat{r}$ such that standardized returns $\tau$ $(\equiv \frac{r-\mu^r}{\sigma^r})$ below $\widehat{r}$ mark the threshold to insolvency. Further, $h(\tau)$ stands for the probability density function and $\sigma^r$ points out that expected *solvency* cost depend on the volatility of aggregate *return*. An increasing level of deposits D raises the threshold level $\widehat{r}$ with $\widehat{r}_D > 0$ and thus sharpens the menace of insolvency. For this reason, the expected *solvency* costs also increase with deposits $(Y_D > 0)$. The impact of a higher level of interest-bearing assets $K$ is less straightforward, as the threshold level $\widehat{r}$ adjusts simultaneously. Once keeping $\widehat{r}$ constant and hence assuming an optimally adjusted liability structure, the expected *solvency* costs depend positively on $K$ as $Y_K^{d\widehat{r}=0} > 0$. Maintaining these assumptions, it turns out that expected *solvency* costs rise with the share of interest bearing assets $Y_\alpha = Y_K A > 0$ , the share of deposits $Y_\beta = Y_D A > 0$ and the total balance sheet $Y_A > 0$. As immediately evident from expression C.9 and C.10, expected solvency cost increase the cost rate $\eta$ with $Y_\eta > 0$.

**Operation Costs** The real costs of running a bank bear similarity with running a non-financial firm once hinting at for instance paying wages or maintaining an office network. Hence, operation costs $\Omega(A, \alpha, \beta)$ increase with the scale of business $\Omega_A > 0$, that is the total balance sheet $A$. More customer-related banking services such as issuing loans and collecting deposits are also costly such that operation costs increase in the share of interest-bearing assets $\Omega_\alpha > 0$ and the share of deposits in overall liabilities $\Omega_\beta > 0$.

### First and Second Order Condition of a Maximum

As put forward by Baltensperger and Milde (1987), banks optimize their expected profits based on three endogenous variables: total balance sheet $A$, the share of interest-bearing assets $\alpha$ and the share of deposits $\beta$. The appendix C.1 provides the details.

$$E[\pi]_A = [\alpha\mu^r - \beta t - (1-\beta)\rho] - \Omega_A - X_A - Y_A = 0 \tag{C.11}$$

$$E[\pi]_\alpha = \mu^r A - \Omega_\alpha - X_\alpha - Y_\alpha = 0 \tag{C.12}$$

$$E[\pi]_\beta = (t-\rho)A - \Omega_\beta - X_\beta - Y_\beta = 0 \tag{C.13}$$

Equations C.11, C.12 and C.13 display the first-order conditions of profit maximization given the balance sheet constraint C.6. Following C.11, a bank raises its total balance sheet until net marginal revenue equals marginal costs. The second first-order conditions C.12 with respect to $\alpha$ refers to the asset side and more specifically states that a bank increases interest-bearing assets against cash holdings until gross marginal revenue balances marginal costs. The third first-order condition C.13 refers to the liability side and demands that a bank increases the share of deposit relative to equity finance until the interest-dividend differential corresponds to the marginal costs of deposit finance.

To accommodate the empirical setup of Section 4.2.2, I adopt the *separation hypothesis* of Baltensperger and Milde (1987). The *separation hypothesis* states that a bank takes the decision about the total balance sheet volume A independent from the structural optimization of $\alpha$ and $\beta$. Put differently, a simultaneous equation system of C.12 and C.13 yields optimal values of mutually dependent $\alpha^*$ and $\beta^*$. Their interconnectedness results from the fact that standard deviations $\sigma^r(D)$ and $\sigma^v(K)$ link the structural parameters of assets $\alpha^*$and liabilities $\beta^*$. Comparative statics below show that a change in exogenous parameters exercises a direct effect on $\alpha^*$ or $\beta^*$(or instantly both) and an indirect effect which runs through the adjustments of standard deviations ($\sigma^r(D)$ and $\sigma^v(K)$ ). As distinct from that, responses of $A^*$and the structural parameters $\alpha^*$ and $\beta^*$ are decoupled by the *separation hypothesis.*

The second-order condition requires that the matrix of second derivatives, the Hessian matrix, must be negative definite for expected profits C.6 to attain a local maximum (see e.g. De la Fuente (2000)). In fact, the *separation hypothesis* has convenient implications for the second-order condition. Expression C.14 displays the Hessian matrix.

$$\Delta' = \begin{bmatrix} E[\pi]_{AA} & E[\pi]_{A\alpha} & E[\pi]_{A\beta} \\ E[\pi]_{\alpha A} & E[\pi]_{\alpha\alpha} & E[\pi]_{\alpha\beta} \\ E[\pi]_{\beta A} & E[\pi]_{\beta\alpha} & E[\pi]_{\beta\beta} \end{bmatrix} \tag{C.14}$$

According to the *separation hypothesis*, interactions between the total balance sheet and structural parameters are shut down ($E[\pi]_{A\alpha} = E[\pi]_{A\beta} = 0$ by symmetry $E[\pi]_{\alpha A} = E[\pi]_{\beta A} = 0$). For this reason, the second order conditions simplifies to:

$$\Delta = \quad E[\pi]_{\alpha\alpha} E[\pi]_{\beta\beta} - E[\pi]^2_{\alpha\beta} \quad > 0 \tag{C.15}$$

$$\textit{with}$$

$$E[\pi]_{AA} < 0 \qquad E[\pi]_{\alpha\alpha} < 0 \qquad E[\pi]_{\beta\beta} < 0$$

As elaborated by Baltensperger and Milde (1987), all elements on the main diagonal are negative ($E[\pi]_{AA} < 0$, $E[\pi]_{\alpha\alpha} < 0$,$E[\pi]_{\beta\beta} < 0$) on account of profit's concavity and by further assumptions do direct effects dominate indirect effects $E[\pi]_{\alpha\alpha} E[\pi]_{\beta\beta} > E[\pi]^2_{\alpha\beta}$ . Hence, a total balance sheet of $A^*$ and structural parameters $\alpha^*$ and $\beta^*$ denote a local maximum of expected profits under the *separation hypothesis* and further assumptions related to cost functions $\Omega$, $X$ and $Y$.

**Comparative statics**

The total balance sheet elasticities C.16 to C.20 and structural elasticities C.21 toC.25 describe the optimal measures for a bank to take once facing the respective exogenous developments on financial markets. A change in exogenous variables impacts differently on the optimal total balance sheet $A^*$ and structural parameters $\alpha^*$ and $\beta^*$. In case of structural parameters, their mutual interplay due to standard deviations captures direct and indirect effects. In case of the total balance sheet, the *separation hypothesis* mutes any repercussion effects.

**Impact on the optimal total balance sheet $A^*$** Expressions C.16 to C.20 list the elasticities of the total balance sheet $A^*$ and rely on the independent first-order condition

C.11, concavity $E\left[\pi\right]_{AA} < 0$ and the *separation hypothesis.*

$$\varepsilon\left(A^{*},\mu^{r}\right) = \frac{-\alpha\mu^{r}}{A^{*}E[\pi]_{AA}} > 0 \tag{C.16}$$

$$\varepsilon\left(A^{*},t\right) = \frac{\beta t}{A^{*}E[\pi]_{AA}} < 0 \tag{C.17}$$

$$\varepsilon\left(A^{*},\rho\right) = \frac{(1-\beta)\rho}{A^{*}E[\pi]_{AA}} < 0 \tag{C.18}$$

$$\varepsilon\left(A^{*},i\right) = \frac{X_{A}}{A^{*}E[\pi]_{AA}} < 0 \qquad i = \Delta\sigma^{v}, p \tag{C.19}$$

$$\varepsilon\left(A^{*},i\right) = \frac{Y_{A}}{A^{*}E[\pi]_{AA}} < 0 \qquad i = \Delta\sigma^{r}, \eta \tag{C.20}$$

Hence, a higher expected return on interest-bearing assets $\mu^{r}$ induces the optimal total balance sheet to expand (Equation C.16). This outcome clearly aligns with the intuition that higher marginal revenues spur the activities of a bank. Disregarding any substitution effects, higher deposit rates $t$ and higher dividends $\rho$ trigger a contraction (Equation C.17 and C.18) as higher marginal costs tend to reduce the business volume. A similar reasoning applies to $p$ and $\eta$ as parameters which shape expected *liquidity* protection and *solvency* costs: higher marginal costs downsize the optimal business volume $A^{*}$.

**Impact on optimal structural parameters $\alpha^{*}$ and $\beta^{*}$** The exogenous impacts on optimal values of structural parameters $\alpha^{*}$ and $\beta^{*}$are more complex to trace. They involve a direct effect as obvious from the first-order conditions as well as an indirect repercussion effect from the respective other side of the balance-sheet. This indirect effect arises from the adjustments in variances and marginal costs.

$$\varepsilon\left(\alpha^{*},\mu^{r}\right) > 0 \quad \varepsilon\left(\beta^{*},\mu^{r}\right) < 0 \tag{C.21}$$

$$\varepsilon\left(\alpha^{*},t\right) > 0 \quad \varepsilon\left(\beta^{*},t\right) < 0 \tag{C.22}$$

$$\varepsilon\left(\alpha^{*},\rho\right) < 0 \quad \varepsilon\left(\beta^{*},\rho\right) > 0 \tag{C.23}$$

$$\varepsilon\left(\alpha^{*},i\right) < 0 \quad \varepsilon\left(\beta^{*},i\right) < 0 \qquad i = \Delta\sigma^{v}, p \tag{C.24}$$

$$\varepsilon\left(\alpha^{*},i\right) < 0 \quad \varepsilon\left(\beta^{*},i\right) < 0 \qquad i = \Delta\sigma^{r}, \eta \tag{C.25}$$

**Penalty rate $p$ and standard deviation of liquidity need $\sigma^v$** The effects exercised by a higher penalty rate $p$ run in parallel to a positive shift in the standard deviation of *liquidity need*$\Delta\sigma^v$. Both raise the marginal costs of *liquidity* protection ($X_{\alpha i}$¿0 and $X_{\beta i} > 0$ for $i = p, \Delta\sigma^v$) leading to a direct negative effect on $\alpha^*$ and $\beta^*$. An indirect effect emerges as relatively lower deposits reduce the variance of the liquidity need ($\sigma^v_D > 0$) which slightly mitigates the reduction in $\alpha^*$due to lower marginal cost of liquidity. Overall, a higher penalty rate $p$ or a positive shift in the standard deviation of *liquidity needs* $\Delta\sigma^v$ diminishes the optimal shares of interest-bearing assets $\alpha^*$ and deposits $\beta^*$. One might relate the Lehman failure to a lasting but sudden shift in the penalty rate $p$ on interbank markets or a structural break in the volatility of liquidity needs $\Delta\sigma^v$.

**Insolvency cost rate $\eta$ and standard deviation of aggregate return $\sigma^r$** A higher insolvency cost rate $\eta$ or a positive shift in the standard deviation returns $\Delta\sigma^r$ imply higher marginal solvency costs ($Y_{\alpha i} > 0$ and$Y_{\beta i} > 0$ for $i = \Delta\sigma^r, \eta$) . The immediate effect reduces $\alpha^*$ and $\beta^*$. This time, an indirect effect dampens the reduction of $\beta^*$ as the substitution away from interest-bearing assets lowers the volume variance $Var\,(rK)$. To sum up, a higher insolvency cost rate $\eta$ or a positive shift in the standard deviation of the aggregate return $\Delta\sigma^r$ reduce the optimal share of interest-bearing assets $\alpha^*$ as well as deposit finance $\beta^*$. Again, one might interpret the Lehman collapse as a permanent shift in parameters: the subsequent firesale of toxic assets can be linked to a change in restructuring costs $\eta$ or a lasting change in the volatility of aggregate returns $\Delta\sigma^r$.

## C.3 Data Appendix

All bank data are obtained from unconsolidated "Balance Sheet Statistics" and the "External Position Report" collected by the *Deutsche Bundesbank*. Section 4.3.1 details on my sample construction. The following list draws on Appendix C.2 displaying an official reporting form whose items I refer to below. Descriptive statistics of all variables are given in Table C.2.

**Total Balance Sheet** POS 330

**Debt** Non-securitized debt: POS 210, POS 220

**Bonds** Securitized debt: POS 230

**Equity** POS310

**Lother** Other liabilities: POS 240, POS 250, POS 260, POS 270, POS 280, POS 290, POS 300, POS 320

**Foreign Debt** Worldwide non-securitized debt, indicated by the "External Position Report"

**Domestic Debt** Difference between domestic and foreign debt.

**Bank Debt** Non-securitized debt vis-à-vis banks, POS 210

**Non-Bank Debt** Non-securitized debt vis-à-vis non-banks, POS 220

**Risk Spread** Difference between Moodys Baa-rated and AAA-rated bonds, see Gatev and Strahan (2006).

## C.4 Graphs and Tables

Figure C.1: A Stylized Bank Balance Sheet


Table C.1: Liability Decompositions

| Set | Liability Decomposition |
|---|---|
| I | $TBS_t = \delta_1^I DEBT_t + \delta_2^I BOND_t + \delta_3^I EQUITY_t + \delta_4^I LOTHER_t$ |
| II | $TBS_t = \delta_1^{II} DEBT\_DOM_t + \delta_2^{II} DEBT\_FOR_t + \delta_3^{II} BOND_t + \delta_4^{II} EQUITY_t + \delta_5^{II} LOTHER_t$ |
| III | $TBS_t = \delta_1^{III} DEBT\_BANK_t + \delta_2^{III} DEBT\_NONB_t + \delta_3^{III} BOND_t + \delta_4^{III} EQUITY_t + \delta_5^{III} LOTHER_t$ |

Notes: $DEBT_t$ non-securitized external debt, $BOND_t$ securitized external debt, $EQUITY_t$ equity, $LOTHER_t$ residual liability category, $DEBT\_DOM_t$ domestic debt, $DEBT\_FOR_t$ foreign debt, $DEBT\_BANK_t$ debt vis-à-vis banks, $DEBT\_NONB_t$ debt vis-a-vis non-banks.

Figure C.2: Official Reporting Forms

# Monthly balance sheet statistics for ____________ (month)

Bank code | Check digit

Name ____________ Location ____________

**Main form, Sheet 3**
**HV21**

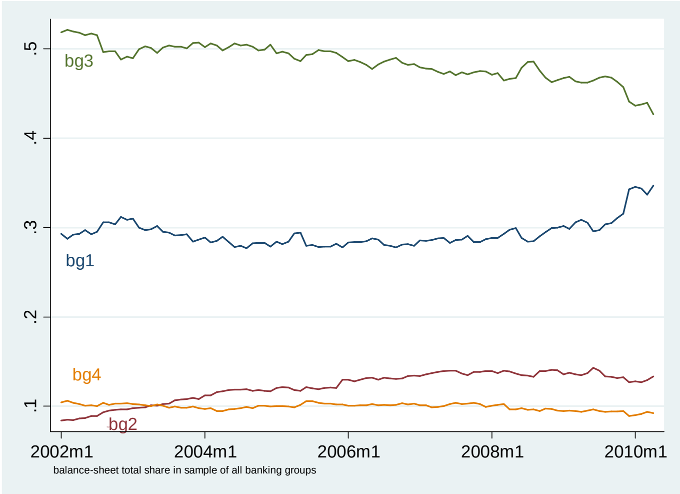
## Liabilities

**– Position as at the end of the month in EUR thousand –**

| | | |
|---|---|---|
| **210** | Liabilities to banks (MFIs) (for building and loan associations: including deposits under savings contracts) | **210** |
| **220** | Liabilities to non-banks (non-MFIs) | |
| **221** | Savings deposits (for building and loan associations: including deposits under savings contracts) | **221** |
| **222** | Other liabilities to non-banks (non-MFIs) | **222** |
| | **Total** | **220** |
| **230** | Securitised liabilities | |
| **231** | Debt securities in issue | **231** |
| **232** | Money market paper in issue | **232** |
| **233** | Own acceptances and promissory notes outstanding | **233** |
| **234** | Other securitised liabilities | **234** |
| | **Total** | **230** |
| **240** | Fiduciary liabilities | |
| **241** | Fiduciary loans | **241** |
| **242** | Securities issued on a fiduciary basis | **242** |
| **243** | Other fiduciary liabilities | **243** |
| | **Total** | **240** |
| **250** | Value adjustments | **250** |
| **260** | Provisions for liabilities and charges | **260** |
| **270** | Blank item | **270** |
| **280** | Subordinated liabilities | **280** |
| **290** | Capital represented by participation rights | **290** |
| **300** | Fund for general banking risks | **300** |
| **310** | Capital | |
| **311** | Subscribed capital | **311** |
| **312** | Reserves | **312** |
| **313** | less published loss | **313** |
| | **Total** | **310** |
| **320** | Other liabilities | |
| **321** | Interest accrued on zero coupon bonds | **321** |
| **322** | Liability item resulting from the refinancing of lease receivables | **322** |
| **323** | Liabilities arising from transactions in goods and from trade credits obtained | **323** |
| **324** | Debit balance on items in the process of settlement | **324** |
| **325** | Debit balance on income and expenditure accounts | **325** |
| **326** | Others | **326** |
| | **Total** | **320** |
| **330** | **Total liabilities** | **330** |
| **340** | Contingent liabilities | |
| **341** | Contingent liabilities arising from the endorsement of rediscounted bills (including bills drawn by the bank) | **341** |
| **342** | Sureties and guarantee agreements | **342** |
| **343** | Assets pledged as collateral on behalf of third parties | **343** |
| | **Total** | **340** |
| **350** | Bills sent for collection from the bill portfolio before maturity | **350** |
| **360** | Volume of business (330 + 341 + 350) | **360** |
| **370** | Commitments deriving from sales with an option to repurchase vis-à-vis | |
| **371** | domestic banks (MFIs) | **371** |
| **372** | domestic non-banks (non-MFIs) | **372** |
| **373** | non-residents | **373** |
| | **Total** | **370** |
| **380** | Placing and underwriting commitments | **380** |
| **390** | Irrevocable lending commitments | **390** |
| | **Total for reconciliation purposes** (380 + 390) | **902** |

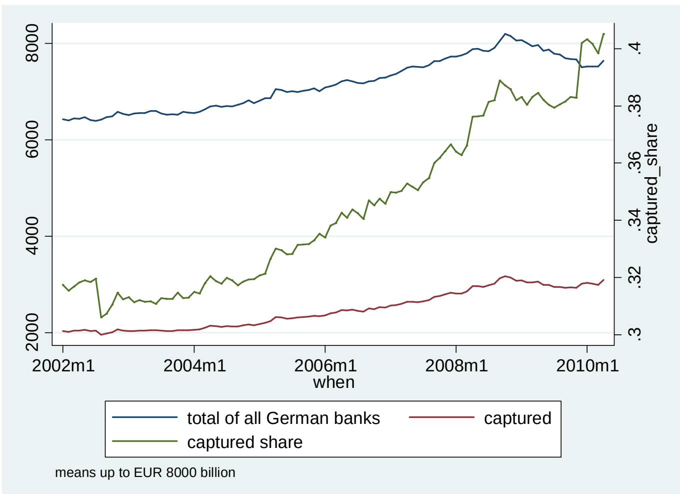
(HV21) 12.2010

Figure C.3: Total Captured by Banking Group



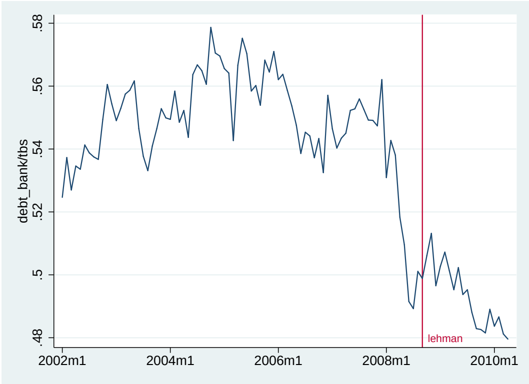

Notes: This graph shows the share of each banking group's total balance-sheet in the total across all banking groups. Bg1 features large commercial banks, bg2 features small commercial banks, bg3 features public sector banks, bg4 features cooperatives banks.

Figure C.4: Total Captured as Share of all German Banks



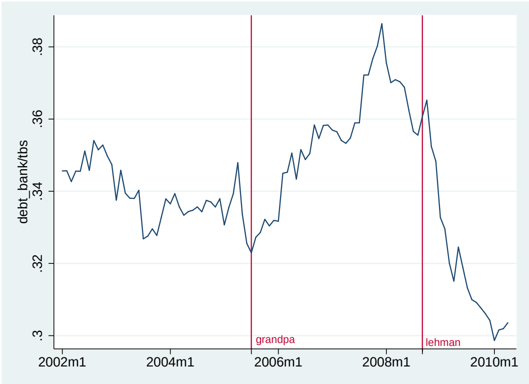

Notes: This graph gives the captured share on the right-hand side axis and the total amounts of the sample as well as the aggregate of all German banks on the left-hand side axis.

Figure C.5: Share of Bank Debt: Cooperative Banks (bg4)




Notes: This graph shows the share of bank debt to the total balance sheet of cooperative banks. The Lehman collapse in September 2008 is indicated by *lehman*.

Figure C.6: Share of Bank Debt: Public Sector Banks (bg3)



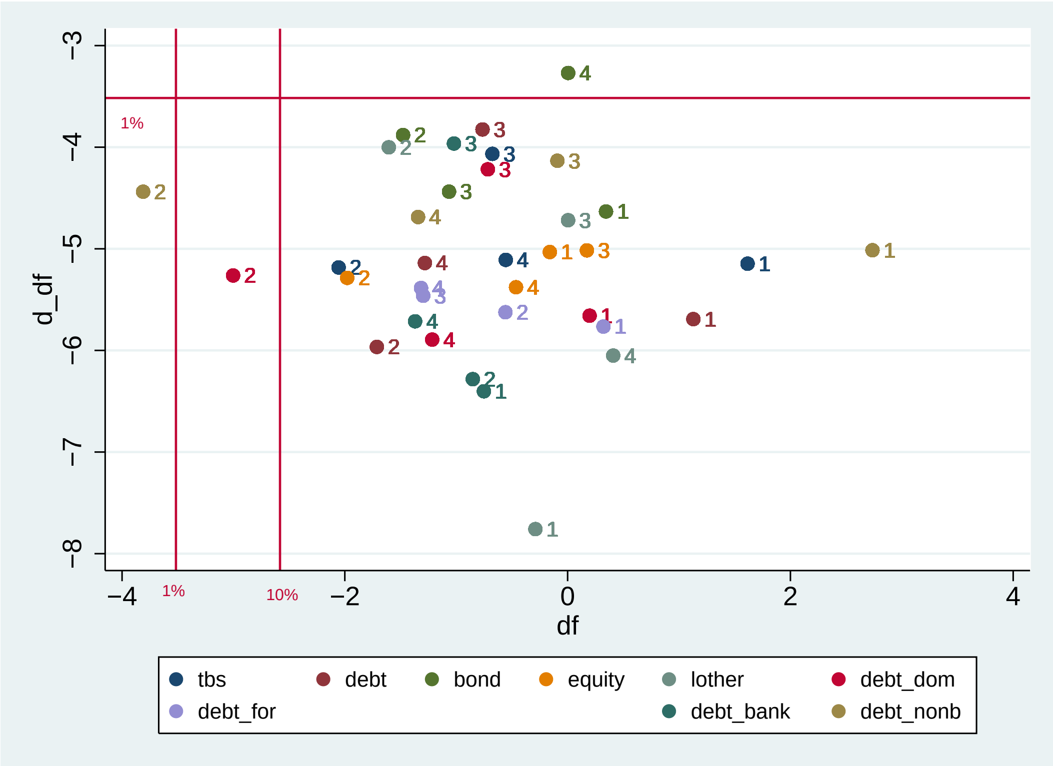

Notes: This graph shows the share of bank debt to the total balance sheet of public sector banks. The Lehman collapse is indicated by *lehman*, the withdrawal of guarantees by *grandpa*.

Table C.2: Descriptive Statistics

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| tbs | 400 | 619.709 | 397.414 | 171.312 | 1490.710 |
| **Liability Items** | | | | | |
| debt | 400 | 418.367 | 237.251 | 125.570 | 933.779 |
| bond | 400 | 123.947 | 132.430 | 17.878 | 412.177 |
| equity | 400 | 24.533 | 14.685 | 5.637 | 57.575 |
| lother | 400 | 52.862 | 30.081 | 14.517 | 127.791 |
| debt_dom | 400 | 288.31 | 161.305 | 104.568 | 720.555 |
| debt_for | 400 | 130.053 | 99.244 | 18.469 | 376.526 |
| debt_bank | 400 | 224.926 | 142.294 | 43.612 | 542.403 |
| debt_nonb | 400 | 193.441 | 107.945 | 36.884 | 410.385 |
| **Exogenous Variable** | | | | | |
| spread_risk | 100 | 1.1937 | 0.5729027 | 0.62 | 3.38 |

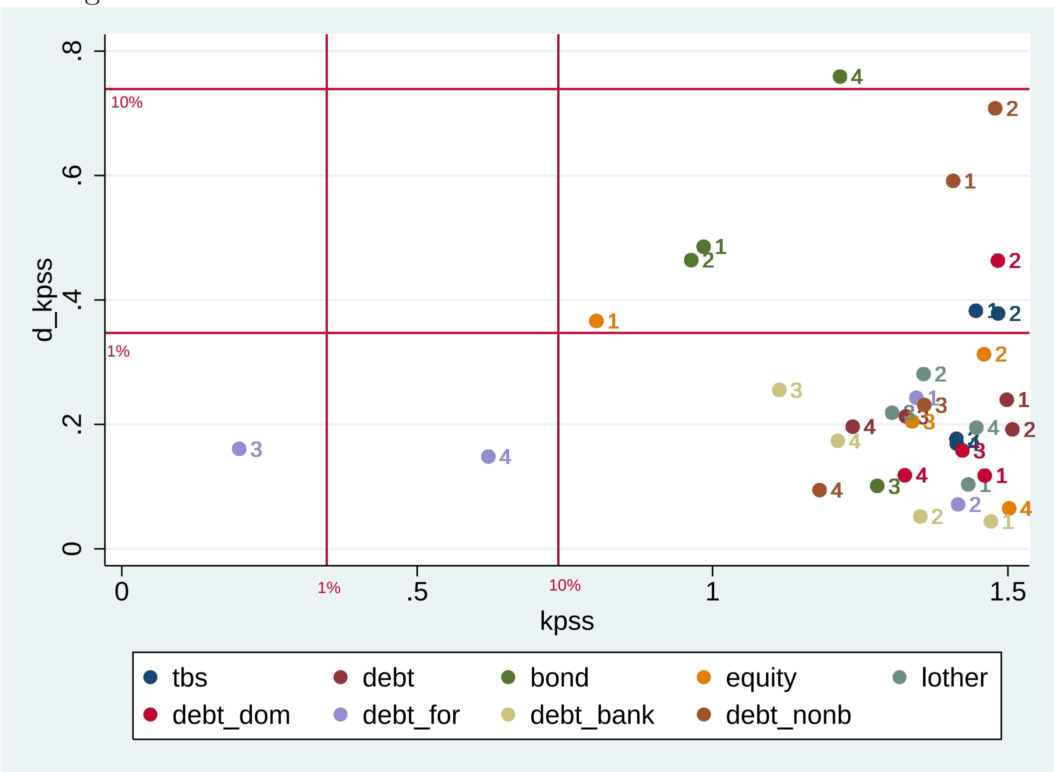
Notes: This table shows descriptive statistics of the total balance sheet (*tbs*) and all balance-sheet items expressed in levels of EUR billions. Data is pooled across all banking groups with each containing 100 observations of monthly data ranging from January 2002 to April 2010. Risk-spread refers do the difference between Moodys Baa-rated and AAA-rated bonds. Further explanations of the codes are provided in Table C.1.

Figure C.7: ADF Test of individual balance-sheet items: Liabilities




Notes: This figure shows the ADF test statistics of individual balance-sheet items in the sets of Table C.1. It plots the first difference in logarithms on the vertical axis against the log-level on the horizontal axis. Numbers refer to banking groups while colors indicate the respective balance-sheet item. Critical values for the rejection of a unit root draw on MacKinnon (2010) and state rejection at the 1% [10%] level of significance at a value of -3.516. [-2.582]. Thus, dots above the 1% line on the horizontal axis and below the 1% line on the vertical axis suggest that a time series has a unit root in log-levels but is stationary in first logged differences. As recommended by Lütkepohl and Krätzig (2004), I rely on the *Schwarz-Bayesian information criterion* (*SBIC*) to determine the optimal lag length of 3 periods. Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks.

Figure C.8: KPSS Test of Individual Balance-Sheet Items: Liabilities




Notes: This figure depicts the *KPSS* test statistics of individual balance-sheet items as described in the sets of Table C.1. It plots the first difference in logarithms on the vertical axis against the log-level on the horizontal axis. Numbers refer to banking groups while colors indicate the respective balance-sheet item. Critical values for the rejection of stationarity draw on Kwiatkowski et al. (1992) and state rejection at the 1% [10%] level of significance at a value of 0.739. [0.347]. Thus, dots above the 10% line on the horizontal axis and below the 10% line on the vertical axis suggest that a time series is not stationary in log-levels but is stationary in first logged differences. I choose a common bandwidth of 6 [5] month in case of levels [first differences] theoretically based on Newey and West (1994). Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks.

Table C.3: Simple Cointegration Tests

| **Engle-Granger Test** | | | | **Shin's KPSS Test** | | | | **Johansen Trace Statistic** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | set I | set II | set III | | set I | set II | set III | | set I | set II | set III |
| bg1 | -5.147* | -4.452 | -6.053* | bg 1 | 0.062 | 0.064 | 0.068 | bg 1 | 1 | 1 | 1 |
| bg2 | -1.931 | -3.855 | -3.990 | bg 2 | 0.132* | 0.039 | 0.146* | bg 2 | 1 | 0 | 0 |
| bg3 | -3.322 | -4.801* | -2.956 | bg 3 | 0.050 | 0.151* | 0.058 | bg 3 | . | 1 | 0 |
| bg4 | -3.675 | -5.093* | -4.381 | bg 4 | 0.094 | 0.065 | 0.085 | bg 4 | 0 | 1 | 1 |
| crit(5%) | -4.211 | -4.558 | -4.588 | crit(5%) | 0.121 | 0.097 | 0.097 | | | | |
| $H_0$ : Non-cointegration, critical values from MacKinnon (2010). | | | | $H_0$ : Cointegration, critical values from Shin (1994) | | | | Because of multicollinearity, bg3, set I cannot be computed. | | | |

Notes: The asterisks denote rejection of the $H_0$ at the 5% level of significance. Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks.

Table C.4: DOLS: Liability Set I

| | bg1 | bg2 | bg3 | bg4 | bg3 | bg3 |
|---|---|---|---|---|---|---|
| debt | 0.765*** | 0.735*** | 0.603*** | 0.726*** | 0.593*** | 0.586*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0) | (0.000) |
| bond | 0.102*** | 0.105*** | 0.298*** | 0.161*** | 0.301*** | 0.303*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0) | (0.000) |
| equity | 0.051*** | 0.060*** | 0.029*** | 0.017*** | 0.0422*** | 0.038*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0) | (0.000) |
| lother | 0.088*** | 0.103*** | 0.071*** | 0.094*** | 0.0737*** | 0.074*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0) | (0.000) |
| iG_debt | | | | | 0.00749 | 0.027*** |
| | | | | | (0.207) | (0.000) |
| iG_bond | | | | | -0.00272 | -0.012*** |
| | | | | | (0.530) | (0.001) |
| iG_equity | | | | | -0.00702 | -0.036*** |
| | | | | | (0.315) | (0.000) |
| iG_lother | | | | | -0.00174 | -0.001 |
| | | | | | (0.697) | (0.905) |
| iL_debt | -0.023*** | 0.054*** | -0.012* | -0.039*** | | -0.012 |
| | (0.003) | (0.002) | (0.077) | (0.000) | | (0.220) |
| iL_bond | -0.017* | -0.016*** | -0.022*** | 0.059*** | | -0.018*** |
| | (0.054) | (0.000) | (0.000) | (0.000) | | (0.009) |
| iL_equity | 0.001 | -0.011 | -0.002 | 0.006 | | 0.031*** |
| | (0.888) | (0.324) | (0.457) | (0.199) | | (0.000) |
| iL_lother | 0.008* | -0.005 | -0.003 | 0.022*** | | -0.003 |
| | (0.064) | (0.521) | (0.435) | (0.000) | | (0.306) |
| grandfa | | | | | 0.0539 | 0.319 |
| | | | | | (0.774) | (0.229) |
| lehman | 0.615** | -0.513 | 0.767*** | -0.771*** | | 0.101 |
| | (0.011) | (0.109) | (0.000) | (0.000) | | (0.635) |
| Constant | 0.677*** | 0.816*** | 0.935*** | 0.858*** | 0.793*** | 0.976*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0) | (0.000) |
| Observations | 97 | 97 | 97 | 97 | 97 | 97 |
| carrion | 0.08 | 0.057 | 0.045 | 0.046 | 0.048 | - |
| chow | 0.0001 | 0 | 0 | 0 | 0.0796 | 0 |
| chi2 | 25.03 | 187.9 | 44.60 | 882.1 | 9849 | 186.7 |

Notes: Interaction terms of variables with the *lehman* [*grandfa*] dummy are coded as $iL^*$ [$iG^*$]. Leads and lags of first differences are not reported but included. *carrion* gives the test statistic of i Silvestre and Sansó (2006) and critical values rely on their simulations of model D: for column 1 to 4 critical values (10%=0.0616; 5%=0.0791; 1%=0.1312) rely on 4 explanatory variables (m=4), and the break fraction $\lambda = 0.2$ ( by symmetry$(1-\lambda) = 0.8 \approx {}^{77}/_{97}$). These critical values indicate rejecting the $H_0$ of cointegration in the presence structural breaks. *chow* presents the p-value of the Chow test, based on the test statistic *chi2* and *df_chow* degrees of freedom. Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks. This table relies on HAC standard errors. Significance indicated by * =10% level, **=5% level, ***=1% level.

Table C.5: DOLS: Liability Set II

| | bg1 | bg2 | bg3 | bg4 | bg3 |
|---|---|---|---|---|---|
| debt_dom | 0.384*** | 0.637*** | 0.445*** | 0.586*** | 0.437*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| debt_for | 0.388*** | 0.111*** | 0.164*** | 0.152*** | 0.168*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| bond | 0.112*** | 0.106*** | 0.288*** | 0.157*** | 0.293*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| equity | 0.039*** | 0.046*** | 0.026*** | 0.016*** | 0.037*** |
| | (0.000) | (0.000) | (0.000) | (0.002) | (0.000) |
| lother | 0.084*** | 0.105*** | 0.069*** | 0.080*** | 0.070*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| iG_debt_dom | | | | | 0.019** |
| | | | | | (0.022) |
| iG_debt_for | | | | | -0.007 |
| | | | | | (0.150) |
| iG_bond | | | | | -0.009 |
| | | | | | (0.130) |
| iG_equity | | | | | -0.036** |
| | | | | | (0.025) |
| iG_lother | | | | | 0.001 |
| | | | | | (0.928) |
| iL_debt_dom | 0.033*** | 0.049*** | 0.006 | -0.012 | -0.002 |
| | (0.001) | (0.002) | (0.693) | (0.196) | (0.914) |
| iL_debt_for | -0.071*** | 0.040*** | -0.036*** | -0.043*** | -0.034*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| iL_bond | -0.023* | 0.007 | -0.020** | 0.051*** | -0.009 |
| | (0.061) | (0.275) | (0.034) | (0.000) | (0.374) |
| iL_equity | 0.006 | 0.040** | -0.009 | 0.010 | 0.017 |
| | (0.596) | (0.016) | (0.151) | (0.360) | (0.247) |
| iL_lother | 0.008 | -0.020** | -0.017** | 0.014*** | -0.019** |
| | (0.214) | (0.030) | (0.019) | (0.002) | (0.026) |
| grandfa | | | | | 0.537 |
| | | | | | (0.194) |
| lehman | 0.931*** | -2.114*** | 1.461*** | -0.336 | 0.910** |
| | (0.001) | (0.000) | (0.002) | (0.170) | (0.043) |
| Constant | 1.172*** | 1.074*** | 1.457*** | 1.322*** | 1.220*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Observations | 97 | 97 | 97 | 97 | 97 |
| chow | 0 | 0 | 0 | 0 | 0 |
| chi2 | 214.1 | 230.7 | 130.4 | 222.9 | 284.2 |

Notes: Interaction terms of variables with the *lehman* [*grandfa*] dummy are coded as $iL^*$ [$iG^*$]. Leads and lags of first differences are not reported but included. *chow* presents the p-value of the Chow test, based on the test statistic *chi2* and *df_chow* degrees of freedom. Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks. This table relies on HAC standard errors. Significance indicated by * =10% level, **=5% level, ***=1% level.

Table C.6: DOLS: Liability Set III

| | bg1 | bg2 | bg3 | bg4 | bg3 |
|---|---|---|---|---|---|
| debt_bank | 0.425*** | 0.216*** | 0.352*** | 0.531*** | 0.343*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| debt_nonb | 0.343*** | 0.514*** | 0.249*** | 0.190*** | 0.246*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| bond | 0.103*** | 0.113*** | 0.297*** | 0.162*** | 0.299*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| equity | 0.051*** | 0.049** | 0.031*** | 0.017*** | 0.039*** |
| | (0.000) | (0.022) | (0.000) | (0.000) | (0.000) |
| lother | 0.085*** | 0.105*** | 0.070*** | 0.099*** | 0.057*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| iG_debt_bank | | | | | 0.019*** |
| | | | | | (0.000) |
| iG_debt_nonb | | | | | -0.005 |
| | | | | | (0.565) |
| iG_bond | | | | | 0.005 |
| | | | | | (0.418) |
| iG_equity | | | | | -0.027*** |
| | | | | | (0.006) |
| iG_lother | | | | | 0.016*** |
| | | | | | (0.003) |
| iL_debt_bank | -0.029*** | -0.005 | -0.030*** | -0.031*** | -0.032** |
| | (0.000) | (0.672) | (0.007) | (0.000) | (0.013) |
| iL_debt_nonb | 0.013 | 0.077 | -0.003 | -0.006 | 0.010 |
| | (0.150) | (0.119) | (0.619) | (0.271) | (0.202) |
| iL_bond | -0.009 | 0.006 | -0.028*** | 0.061*** | -0.049*** |
| | (0.486) | (0.686) | (0.000) | (0.000) | (0.000) |
| iL_equity | -0.009 | 0.024 | -0.009 | -0.005 | 0.016 |
| | (0.241) | (0.410) | (0.301) | (0.395) | (0.272) |
| iL_lother | 0.007* | -0.020* | -0.006 | 0.020*** | -0.013* |
| | (0.063) | (0.083) | (0.192) | (0.000) | (0.079) |
| grandfa | | | | | -0.196 |
| | | | | | (0.515) |
| lehman | 0.547* | -1.544 | 1.484*** | -0.670*** | 1.361*** |
| | (0.086) | (0.156) | (0.000) | (0.002) | (0.007) |
| Constant | 1.200*** | 1.385*** | 1.403*** | 1.274*** | 1.696*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Observations | 97 | 97 | 97 | 97 | 97 |
| chow | 0 | 0.0188 | 0 | 0 | 0 |
| chi2 | 51.26 | 15.20 | 186.0 | 504.8 | 643.6 |
| df_chow | 6 | 6 | 6 | 6 | 12 |

Notes: Interaction terms of variables with the *lehman* [*grandfa*] dummy are coded as $iL^*$ [$iG^*$]. Leads and lags of first differences are not reported but included. *chow* presents the p-value of the Chow test, based on the test statistic *chi2* and *df_chow* degrees of freedom. Bg1 features large commercial banks, bg2 small commercial banks, bg3 public sector banks and bg4 cooperative banks. This table relies on HAC standard errors. Significance indicated by * =10% level, **=5% level, ***=1% level.

Table C.7: VECM Liability Set I

| | D.tbs | D.debt | D.bond | D.equity | D.lother |
|---|---|---|---|---|---|
| **bg1** | | | | | |
| L.coint_spread | 0.020* | 0.022 | 0.022 | 0.022** | -0.004 |
| L.coint_identity | -4.029*** | -4.393*** | -2.211 | -3.253*** | -2.506* |
| LD.spread_risk | 0.049 | 0.047 | 0.122* | 0.008 | 0.016 |
| LD.tbs | 6.614* | 9.019* | 0.941 | 3.648 | -5.490 |
| LD.debt | -4.957* | -6.797* | -0.688 | -2.626 | 4.287 |
| LD.bond | -0.706* | -1.001* | -0.046 | -0.390 | 0.849 |
| LD.equity | -0.275 | -0.375 | 0.274 | -0.168 | -0.088 |
| LD.lother | -0.785** | -0.968** | -0.332 | -0.517* | 0.206 |
| Constant | 0.000 | -0.000 | 0.004 | -0.003 | 0.001 |
| Observations | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.003 | 0.339 | 0.015 | 0.005 |
| $R^2$ | 0.330 | 0.267 | 0.128 | 0.228 | 0.255 |
| **bg2** | | | | | |
| L.coint_spread | -0.004 | -0.008 | -0.009 | 0.002 | 0.025 |
| L.coint_identity | -2.893* | -4.248** | -6.156 | 5.457*** | 5.747 |
| LD.spread_risk | 0.011 | 0.014 | 0.017 | -0.063 | 0.024 |
| LD.tbs | 0.331 | 2.102 | -0.621 | -2.074 | -6.904 |
| LD.debt | -0.375 | -1.629 | 0.235 | 1.444 | 4.669 |
| LD.bond | -0.031 | -0.207 | 0.046 | 0.216 | 0.706 |
| LD.equity | 0.103 | -0.055 | 1.062* | 0.115 | 0.071 |
| LD.lother | -0.029 | -0.202 | 0.259 | 0.196 | 0.466 |
| Constant | 0.014*** | 0.016*** | 0.008 | 0.006 | 0.015* |
| Observations | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.000 | 0.009 | 0.002 | 0.012 |
| $R^2$ | 0.359 | 0.306 | 0.241 | 0.272 | 0.235 |
| **bg4** | | | | | |
| L.coint_spread | -0.013 | -0.024** | 0.012 | -0.001 | 0.019 |
| L.coint_identity | 0.225 | -0.013 | 1.458*** | -0.169 | -0.141 |
| LD.spread_risk | 0.041 | 0.035 | 0.047 | 0.060** | 0.090 |
| LD.tbs | -1.170 | 2.248 | -10.654** | -2.330 | -9.955 |
| LD.debt | 0.889 | -1.708 | 8.026** | 1.741 | 7.711 |
| LD.bond | 0.180 | -0.317 | 1.335 | 0.421 | 1.842 |
| LD.equity | -0.065 | -0.216 | 0.092 | 0.005 | 0.973** |
| LD.lother | -0.002 | -0.262 | 0.721* | 0.209 | 0.629 |
| Constant | 0.003 | 0.002 | 0.002 | 0.005*** | 0.004 |
| Observations | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.005 | 0.099 | 0.000 | 0.033 | 0.017 |
| $R^2$ | 0.257 | 0.176 | 0.417 | 0.208 | 0.226 |

Notes: This table shows the result of a VECM estimation. *D* denotes first differences, *LD* denotes lagged first differences, *L* denotes one lag. Results rely on the reduced sample prior to the structural break of the Lehman collapse in 2008m9. Bg3 provides too few observations prior to its first structural break in July 2005 and is hence omitted. Risk-spread is modeled as weakly exogenous variable subject to constraints in order to allow for the persistence of the variable. Estimation results on the risk-spread equation are however not reported. *coint_spread* refers to the first cointegration term featuring the and imposed coefficients of zero on the balance-sheet variables. The *coint_identity* refers to the second cointegration term which features only balance-sheet variables and an imposed zero coefficient on risk-spread. *Pval(df, chi2)* gives the p-value of the test of joint significance of all included variables in the respective equation; $R^2$ gives the share of variance explained by included variables in the respective equation. Bg1 features large commercial banks, bg2 small commercial banks and bg4 cooperative banks. Significance is indicated by *=10% level, **=5% level, ***=1% level.

Table C.8: VECM Liability Set II

| | D.tbs | D.debt_dom | D.debt_for | D.bond | D.equity | D.lother |
|---|---|---|---|---|---|---|
| **bg1** | | | | | | |
| L.coint_spread | 0.023* | 0.018 | 0.031 | 0.024 | 0.028*** | -0.003 |
| L.coint_identity | -3.067*** | -1.998* | -4.772*** | -1.178 | -3.124*** | -2.012* |
| LD.spread_risk | 0.045 | 0.083 | -0.002 | 0.126* | 0.012 | 0.034 |
| LD.tbs | 4.744** | 4.382 | 6.630 | 7.707* | 0.291 | -2.962 |
| LD.debt_dom | -1.859** | -1.911 | -2.371 | -3.230** | 0.010 | 1.288 |
| LD.debt_for | -1.727** | -1.458 | -2.603 | -2.704* | -0.071 | 1.129 |
| LD.ln_vewp | -0.497** | -0.429 | -0.784 | -0.802* | -0.023 | 0.549 |
| LD.equity | -0.219 | -0.008 | -0.495 | -0.128 | -0.004 | -0.194 |
| LD.lother | -0.578** | -0.551 | -0.652 | -0.936** | -0.219 | -0.045 |
| Constant | 0.002 | 0.007* | -0.004 | 0.007 | -0.003 | 0.002 |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.001 | 0.021 | 0.057 | 0.063 | 0.002 | 0.010 |
| $R^2$ | 0.306 | 0.236 | 0.208 | 0.205 | 0.287 | 0.255 |
| **bg2** | | | | | | |
| L.coint_spread | 0.012 | 0.008 | 0.054 | 0.018 | -0.034*** | 0.020 |
| L.coint_identity | 1.718** | 0.941 | 11.409*** | 2.952 | -4.242*** | -0.457 |
| LD.spread_risk | -0.009 | -0.040 | 0.153 | -0.026 | -0.042 | 0.058 |
| LD.tbs | 1.161 | 1.104 | 3.398 | 3.941 | 2.703 | -2.444 |
| LD.debt_dom | -1.018 | -0.933 | -2.423 | -2.971 | -1.685 | 1.109 |
| LD.debt_for | -0.077 | -0.052 | -0.326 | -0.339 | -0.360** | 0.230 |
| LD.ln_vewp | -0.116 | -0.110 | -0.277 | -0.406 | -0.257 | 0.199 |
| LD.equity | 0.115 | 0.057 | -0.038 | 0.903*** | -0.221 | -0.143 |
| LD.lother | -0.128 | -0.078 | -0.544 | -0.233 | -0.318* | -0.024 |
| Constant | 0.011*** | 0.010*** | 0.010 | 0.001 | 0.012*** | 0.027*** |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.000 | 0.014 | 0.006 | 0.000 | 0.031 |
| $R^2$ | 0.409 | 0.380 | 0.247 | 0.266 | 0.361 | 0.226 |
| **bg4** | | | | | | |
| L.coint_spread | -0.016** | -0.007 | -0.101** | 0.001 | 0.001 | 0.012 |
| L.coint_identity | -0.203 | -0.081 | 0.010 | -1.317*** | 0.136 | 0.494 |
| LD.spread_risk | 0.050* | 0.007 | 0.205 | 0.044 | 0.053** | 0.108 |
| LD.tbs | 1.059 | 1.619 | 1.777 | 0.866 | -0.836 | -1.527 |
| LD.debt_dom | -0.721 | -0.866 | -2.319 | -0.604 | 0.568 | 1.160 |
| LD.debt_for | -0.117 | -0.173 | -0.416 | -0.087 | 0.121 | 0.337 |
| LD.ln_vewp | -0.222 | -0.137 | -0.990 | -0.556** | 0.198 | 0.554 |
| LD.equity | -0.094 | -0.060 | -0.705 | -0.214 | -0.047 | 0.798** |
| LD.lother | -0.151 | -0.333** | 0.367 | -0.103 | 0.076 | -0.010 |
| Constant | 0.002 | 0.003 | -0.000 | 0.002 | 0.005*** | 0.004 |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.008 | 0.010 | 0.000 | 0.062 | 0.026 |
| $R^2$ | 0.335 | 0.260 | 0.255 | 0.410 | 0.206 | 0.231 |

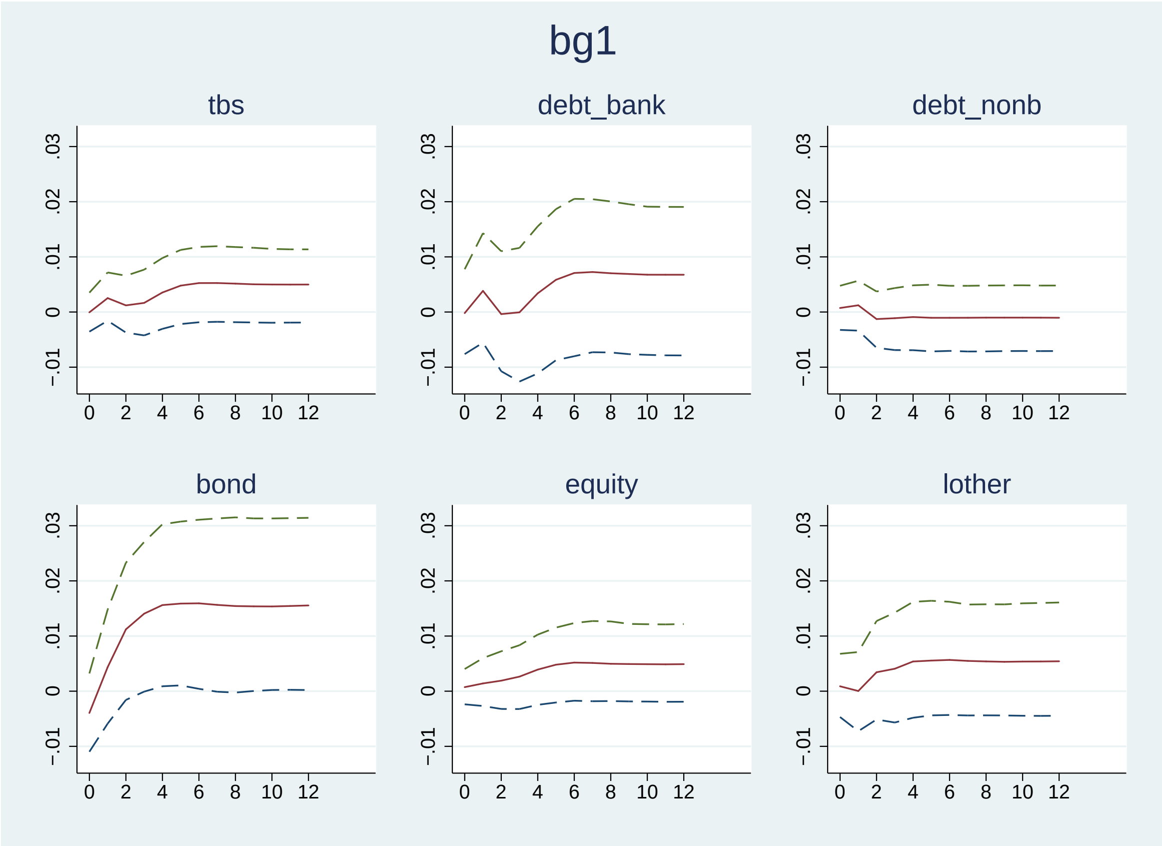
Notes: This table shows the result of a VECM estimation. *D* denotes first differences, *LD* denotes lagged first differences, *L* denotes one lag. Results rely on the reduced sample prior to the structural break of the Lehman collapse in 2008m9. Bg3 provides too few observations prior to its first structural break in July 2005 and is hence omitted. Risk-spread is modeled as weakly exogenous variable subject to constraints in order to allow for the persistence of the variable. Estimation results on the risk-spread equation are however not reported. *coint_spread* refers to the first cointegration term featuring the and imposed coefficients of zero on the balance-sheet variables. The *coint_identity* refers to the second cointegration term which features only balance-sheet variables and an imposed zero coefficient on risk-spread. *Pval(df, chi2)* gives the p-value of the test of joint significance of all included variables in the respective equation; $R^2$ gives the share of variance explained by included variables in the respective equation. Bg1 features large commercial banks, bg2 small commercial banks and bg4 cooperative banks. Significance is indicated by *=10% level, **=5% level, ***=1% level.

Table C.9: VECM Liability Set III

| | D.tbs | D.debt_bank | D.debt_nonb | D.bond | D.equity | D.lother |
|---|---|---|---|---|---|---|
| **bg1** | | | | | | |
| L.coint_spread | 0.017 | 0.044* | -0.015 | 0.020 | 0.019* | -0.003 |
| L.coint_identity | -3.177*** | -6.008*** | -0.310 | -1.611 | -2.443*** | -2.200** |
| LD.spread_risk | 0.045 | 0.043 | 0.046 | 0.114 | 0.005 | 0.007 |
| LD.tbs | 3.993 | 10.191* | 1.062 | 1.828 | 3.011 | -7.893* |
| LD.debt_bank | -1.627 | -4.143* | -0.503 | -0.779 | -1.180 | 3.378** |
| LD.debt_nonb | -1.398 | -3.430* | -0.598 | -0.447 | -0.972 | 2.739** |
| LD.bond | -0.428 | -1.283* | 0.028 | -0.123 | -0.326 | 1.095** |
| LD.equity | -0.144 | -0.108 | -0.358* | 0.206 | -0.141 | 0.034 |
| LD.lother | -0.547* | -1.194* | -0.103 | -0.443 | -0.465* | 0.443 |
| Constant | 0.001 | -0.001 | 0.003 | 0.004 | -0.003 | 0.001 |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.003 | 0.008 | 0.401 | 0.033 | 0.001 |
| $R^2$ | 0.341 | 0.285 | 0.260 | 0.133 | 0.224 | 0.297 |
| **bg2** | | | | | | |
| L.coint_spread | 0.017 | 0.108** | 0.007 | -0.082* | -0.005 | 0.005 |
| L.coint_identity | -0.287 | -2.036*** | -0.036 | 1.146** | 0.085 | 0.226 |
| LD.spread_risk | -0.010 | 0.044 | -0.053* | -0.029 | -0.030 | 0.067 |
| LD.tbs | -1.228 | -1.222 | -2.239 | 4.075 | -1.617 | -1.304 |
| LD.debt_bank | 0.286 | 0.611 | 0.466 | -0.971 | 0.289 | 0.049 |
| LD.debt_nonb | 0.345 | -0.226 | 0.964 | -2.340 | 0.871 | 0.714 |
| LD.bond | 0.132 | 0.033 | 0.268* | -0.357 | 0.126 | 0.110 |
| LD.equity | 0.242* | 0.637* | 0.176 | 0.450 | 0.114 | -0.271 |
| LD.lother | 0.122 | 0.178 | 0.206 | -0.221 | 0.141 | -0.105 |
| Constant | 0.013*** | 0.009 | 0.015*** | 0.003 | 0.010*** | 0.022*** |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval(df,chi2) | 0.000 | 0.023 | 0.000 | 0.003 | 0.076 | 0.027 |
| $R^2$ | 0.378 | 0.234 | 0.462 | 0.280 | 0.199 | 0.230 |
| **bg4** | | | | | | |
| L.coint_spread | -0.017** | -0.028* | -0.001 | -0.020 | 0.003 | 0.014 |
| L.coint_identity | -1.336 | -1.333 | -0.390 | -5.429*** | 0.060 | 6.390** |
| LD.spread_risk | 0.044* | 0.062 | -0.054 | 0.083** | 0.053** | 0.087 |
| LD.tbs | -0.317 | -1.824 | 1.202 | 2.631 | -1.316 | 2.856 |
| LD.debt_bank | 0.217 | 0.894 | -0.289 | -1.336 | 0.745 | -1.457 |
| LD.debt_nonb | 0.050 | 0.399 | -0.541 | -0.439 | 0.299 | -0.476 |
| LD.bond | 0.055 | 0.285 | -0.164 | -0.637 | 0.218 | 0.026 |
| LD.equity | -0.087 | -0.065 | -0.404 | -0.143 | 0.001 | 0.594 |
| LD.lother | -0.073 | 0.038 | -0.134 | -0.334 | 0.106 | -0.313 |
| Constant | 0.002 | -0.001 | 0.007 | 0.002 | 0.005** | 0.003 |
| Observations | 78 | 78 | 78 | 78 | 78 | 78 |
| Pval (df,chi2) | 0.008 | 0.280 | 0.100 | 0.005 | 0.090 | 0.006 |
| $R^2$ | 0.260 | 0.151 | 0.190 | 0.273 | 0.194 | 0.267 |

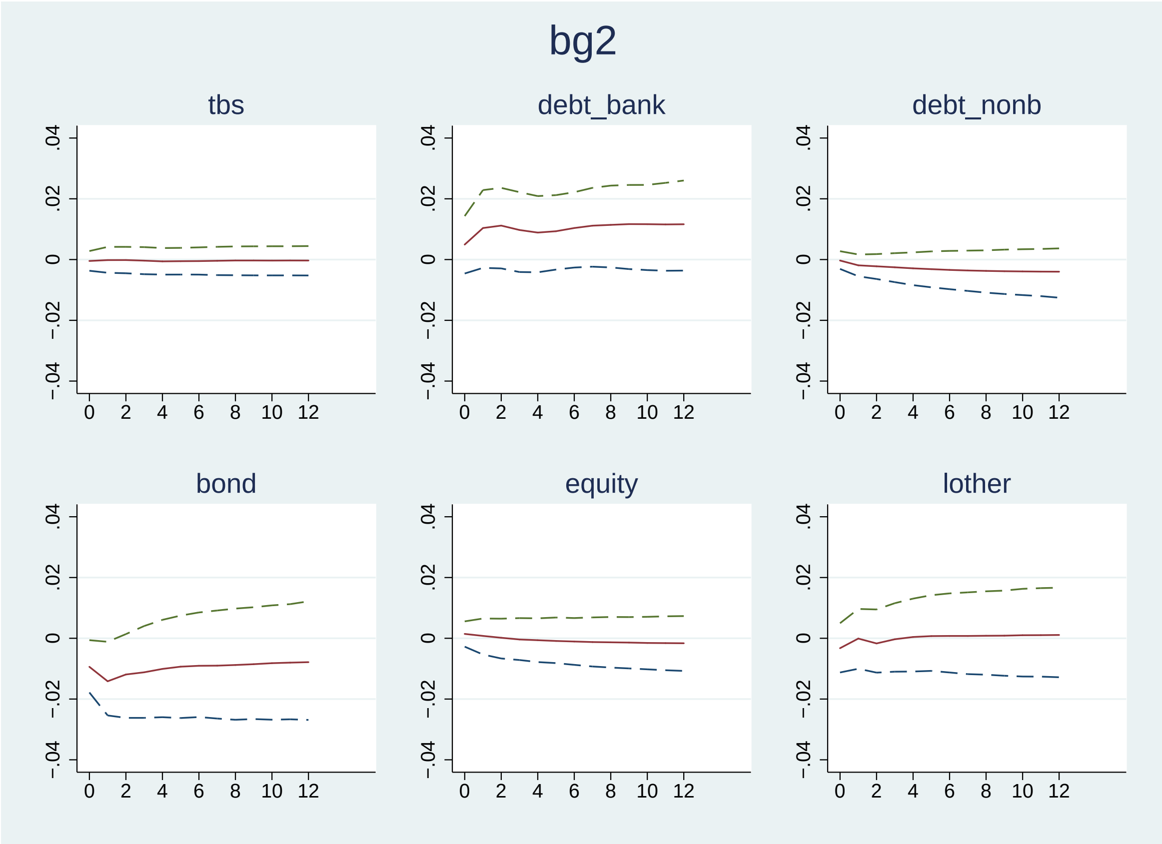
Notes: This table shows the result of a VECM estimation. *D* denotes first differences, *LD* denotes lagged first differences, *L* denotes one lag. Results rely on the reduced sample prior to the structural break of the Lehman collapse in 2008m9. Bg3 provides too few observations prior to its first structural break in July 2005 and is hence omitted. Risk-spread is modeled as endogenous variable subject to constraints in order to allow for the persistence of the variable. Estimation results on the risk-spread equation are however not reported. The *ce_term_1* refers to the first cointegration term featuring risk-spread being cointegrated with itself and imposed coefficients of zero on the balance-sheet variables. The *ce_term_2* refers to the second cointegration term which features only balance-sheet variables and an imposed zero coefficient on risk-spread. *Pval(df, chi2)* gives the p-value of the test of joint significance of all included variables in the respective equation; *R2* gives the share of variance explained by included variables in the respective equation. Bg1 features large commercial banks, bg2 small commercial banks and bg4 cooperative banks. Significance is indicated by *=10% level, **=5% level, ***=1% level.

Figure C.9: Impulse Response Functions: Large Commercial Banks



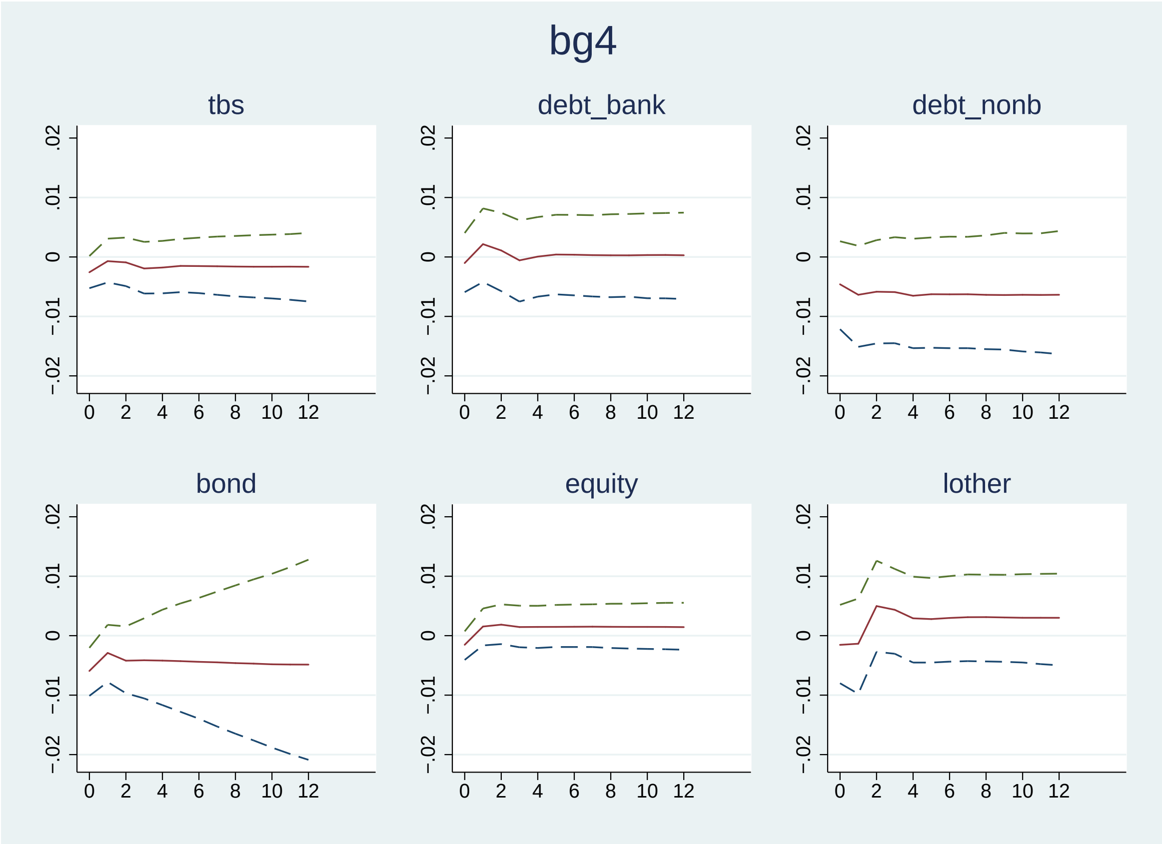

Notes: This figure shows bootstrapped impulse response functions of liability set III induced by a one percent change in the risk spread for large commercial banks. The green (blue) dashed line marks the upper (lower) bound of the 90% confidence interval based on a horizon of 12 months and 1000 replications.

Figure C.10: Impulse Response Function: Small Commercial Banks




Notes: This figure shows bootstrapped impulse response functions of liability set III induced by a one percent change in the risk spread for small commercial banks. The green (blue) dashed line marks the upper (lower) bound of the 90% confidence interval based on a horizon of 12 months and 1000 replications.

Figure C.11: Impulse Response Function: Cooperative Banks




Notes: This figure shows bootstrapped impulse response functions of liability set III induced by a one percent change in the risk spread for cooperative banks. The green (blue) dashed line marks the upper (lower) bound of the 90% confidence interval based on a horizon of 12 months and 1000 replications.

# 5

# Concluding Remarks and Outlook

As *Bank of England* governor Mervyn King[1] recognizes "... most large complex financial institutions are global – at least in life not in death.". In line with this telling statement, my thesis has pointed at the key role of banks' international activities once revising regulatory standards after the financial crisis. However, without loss of generality, heterogeneities among banks in terms of their business model, their funding structure and institutional background form the nuances of my results.

The first paper has pointed out that bank-level productivity shapes banks' venturing abroad. As distinct from small non-financial firms, even small banks conduct some kind of international business. Our findings suggest that more complex and more costly modes of internationalization demand greater productivity. Gravity variables, portfolio considerations and bank-level risk factors matter as well.

More complex modes of foreign activity broaden a bank's scope of funding sources as well as markets to service. Most foreign operations are not self-contained. Foreign affiliates can tab local sources of liquidity and thereby contribute to the well functioning of a bank's internal capital market. Yet, recent work (see e.g. Cetorelli and Goldberg, 2011) has pointed at the role of internal capital markets in the global propagation of shocks. As to emerging markets, their banking authorities recognize that parent banks in developed countries can be a source of support as well as instability. Regulators aim to "ring-fence" foreign commercial presence of banks, meaning that funding operations of foreign subsidiaries do neither draw resources from parent banks nor does money flow

[1]Speech by Mr Mervyn King, *Governor of the Bank of England*, at the Second Bagehot Lecture, Buttonwood Gathering, New York, 25 October 2010.

out of the host country. These policy initiatives would paralyze internal capital markets and more distinctly split foreign from domestic operations. One might interpret these initiatives as a step towards financial market disintegration. The effect on the parent bank's business model and lending practices is an interesting topic for future research.

The second paper studies the risk-market power nexus for banks from an international angle. As regards the nexus in isolation, it finds a negative correlation between market power and risk. As regards the impact of international activity in terms of higher volume (*intensive* margin), we find that a higher intensity of foreign operations raises both market power and risk. As regards the impact of entering more foreign markets (the *extensive* margin), we find that banks venturing in more countries see their market power decline at home and further do they experience fewer distress events. Yet, evidence on the impact on bank risk is rather weak and our core results seem to be driven by international operations of foreign branches rather than cross-border activities.

Common knowledge suggests that financial market integration goes along with two effects. On the one hand, banks become more diversified. On the other hand, banks are exposed to more risks. The banking crisis has demonstrated that the benefits of financial integration in terms of a more efficient international risk allocation are fairly illusive. Further, understanding the mutual interplay of market power and risk in light of financial market integration is important for policy makers. Repercussion effects from international operations crucially impact the unfolding of macroprudential policy tools such as procyclical capital buffers. Further, resolving global banks is difficult with foreign subsidiaries being subject to foreign supervision. So-called "living wills" jointly drafted by banks and regulators shall provide a manual of how to handle severe distress events or even the resolution of global banks. Future research might discuss how these "living wills" shape the risk-market power nexus.

The third paper addresses the short- and long-run view on leverage and other liability ratios. My long-run approach finds that key ruptures in the funding conditions of banks trigger major reallocations in the liability structure and hence leverage. My short-run approach finds that considerable heterogeneity governs the adjustment patterns of banking groups in view of changing financial market risks.

Besides immediate effects of shock events or changes in financial market risks, indirect effects emerge. Apart from the intrabank and interbank market, risk panics, firesales and more generally speaking the devaluation of collateral reinforce these shocks. Lucas and Stokey (2011) state that the financial market freeze in September 2008 was a type of modern bank run. Regulatory standards have to cope with these reinforcing external effects. Ever since, the inter-bank market has not fully recovered. To ease the euro-area strains, the ECB has provided huge amounts of liquidity. Small international business and trade finance crucially rely on banks. With banks withdrawing from the international stage, financial markets seem to disintegrate suggesting harder times to finance cross-border trade and foreign direct investment. One might ask whether banks prioritize domestic customers and whether the ECB initiative has achieved the aim to re-animate cross-border lending. All these questions provide fruitful avenues for future research.

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# CURRICULUM VITAE

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